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PRACTICE PAPER-XII

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MPP
(XI & XII)

GEAR UP FOR AIIMS

PHYSICS for you

Volume 26 No. 3 March 2018

Managing Editor
Mahabir Singh

Editor
Anil Ahlawat

Corporate Office:
Plot 99, Sector 44 Institutional area, Gurgaon -122 003 (HR).
Tel : 0124-6601200 e-mail : info@mtg.in website : www.mtg.in

Regd. Office:
406, Taj Apartment, Near Safdarjung Hospital, New Delhi - 110029.

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Printed and Published by Mahabir Singh on behalf of MTG Learning Media Pvt. Ltd. Printed at HT Media Ltd., B-2, Sector-63, Noida, UP-201307 and published at 406, Taj Apartment, Ring Road, Near Safdarjung Hospital, New Delhi - 110029.
Editor : Anil Ahlawat

PHYSICS MUSING

Physics Musing was started in August 2013 issue of Physics For You. The aim of Physics Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / NEET / AIIMS / JIPMER with additional study material.

In every issue of Physics For You, 10 challenging problems are proposed in various topics of JEE (Main and Advanced) / NEET. The detailed solutions of these problems will be published in next issue of Physics For You.

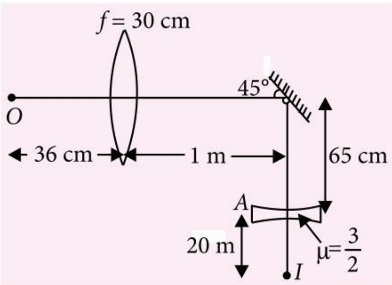
The readers who have solved five or more problems may send their detailed solutions with their names and complete address. The names of those who send atleast five correct solutions will be published in the next issue.

We hope that our readers will enrich their problem solving skills through "Physics Musing" and stand in better stead while facing the competitive exams.

PROBLEM Set 56

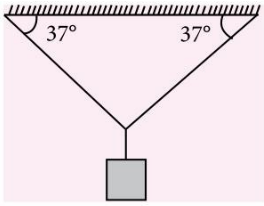
SUBJECTIVE TYPE

1. The final image I of the object O shown in the figure is formed at point 20 cm below a thin equal-concave lens, which is at a depth of 65 cm from principal axis of a convex lens. From the given geometry, calculate the radius of curvature (in cm) of lens kept at A.

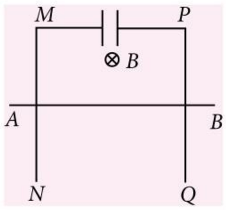


2. Two persons A and B wear glasses of optical powers (in air) $P_1 = +2$ D and $P_2 = +1$ D respectively. The glasses have refractive index 1.5. Now they jump into a swimming pool and look at each other. B appears to be present at distance 2 m (from A) to A. A appears to be present at distance 1 m (from B) to B. Find out the refractive index of water in the swimming pool.

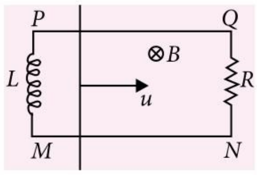
3. A block is hanged by means of two identical wires having cross section area 1 mm^2 as shown in the diagram. If temperature is lowered by 10°C, find the mass (in kg) to be added to hanging mass such that junction remains at initial position. Given that co-efficient of linear expansion $\alpha = 2 \times 10^{-5}$ °C^{-1} and Young's modulus $Y = 5 \times 10^{11}$ N m^{-2} for the wire.



4. In the figure shown, a conducting rod AB of length l, resistance R and mass m can move vertically downward due to gravity. Other parts are kept fixed. B = constant = B_0. MN and PQ are vertical, smooth, conducting rails. The capacitance of the capacitor is C. The rod is released from rest. Find the maximum current in the circuit.



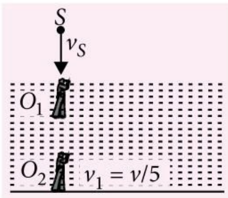
5. In the figure, a conducting rod of length $l = 1$ m and mass $m = 1$ kg moves with initial velocity $u = 5$ m s^{-1} on a fixed horizontal frame containing inductor $L = 2$ H and resistance $R = 1\ \Omega$. PQ and MN are smooth, conducting wires. There is a uniform magnetic field of strength $B = 1$ T. Initially there is no current in the inductor. Find the total charge flown through the inductor by the time velocity of rod becomes $v_f = 1$ m s^{-1} and the rod has travelled a distance $x = 3$ m.



6. A uniform rod of mass m is hinged at a point $L/4$ from one end of the rod and is at rest. An impulse I is imparted on the other end of the rod perpendicular to it. Find the angular speed of the rod just after the application of the impulse.

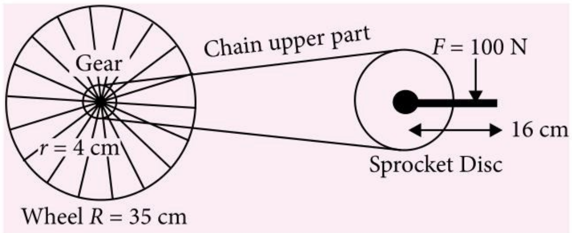
By Akhil Tewari, Author Foundation of Physics for JEE Main & Advanced, Professor, IITians PACE, Mumbai.

7. In the figure shown an observer O_1 floats (static) on water surface with ears in air while another observer O_2 is moving upwards with constant velocity $v_1 = v/5$ in water. The source moves down with constant velocity $v_S = v/5$ and emits sound of frequency υ. The velocity of sound in air is v and that in water is $4v$. Find the frequency of sound received by O_2.



COMPREHENSION TYPE

A bicycle has pedal rods of length 16 cm connected to a sprocketed disc of radius 10 cm. The bicycle wheels are 70 cm in diameter and the chain runs over a gear of radius 4 cm. The speed of the cycle is constant and the cyclist applies 100 N force that is always perpendicular to the pedal rod, as shown. Assume tension in the lower part of chain negligible. The cyclist is peddling at a constant rate of 2 rps. Assume that the force applied by other foot is zero when one foot is exerting 100 N force. Neglect friction within cycle parts and the rolling friction.



8. The tension in the upper portion of the chain is equal to

(a) 100 N (b) 120 N
(c) 160 N (d) 240 N

9. The power delivered by the cyclist is equal to

(a) 28π W (b) 10π W
(c) 64π W (d) 32π W

10. The net force of the friction on the rear wheel due to the road is

(a) 100 N (b) 62 N
(c) 32.6 N (d) 18.3 N

PRACTICE PAPER 2018
JEE MAIN

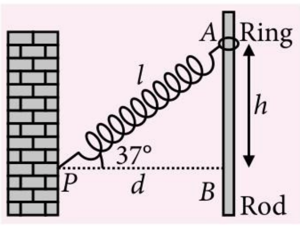
Exam on
8th April (Offline)
15th & 16th April (Online)

1. A man is in a satellite which is at a distance of 2000 km from the surface of the earth. The man has to be thrown out so that he can escape the earth completely. With what velocity should he be thrown out?

(a) $\sqrt{\dfrac{2GM}{R}}$ (b) $\sqrt{\dfrac{2GM}{R+2000}}$

(c) $\sqrt{\dfrac{GM}{R+2000}}$ (d) $\dfrac{1}{20}\sqrt{\dfrac{GM}{5}}$

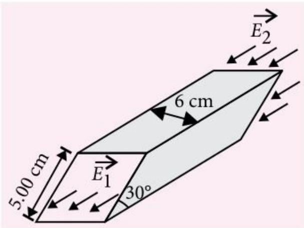
2. One end of a light spring of natural length d and spring constant k is fixed on a rigid wall and the other end is attached to a smooth ring of mass m which can slide without friction on a vertical rod fixed at a distance d from the wall. Initially the spring makes an angle of 37° with the horizontal as shown in figure. When the system is released from rest, find the speed of the ring when the spring becomes horizontal. ($\sin 37° = 3/5$)



(a) $d\sqrt{\dfrac{3g}{2d}+\dfrac{k}{16m}}$ (b) $d\sqrt{\dfrac{4g}{3d}+\dfrac{k}{4m}}$

(c) $\sqrt{3gd-\dfrac{kl^2}{4m}}$ (d) $l\sqrt{\dfrac{3g}{2d}-\dfrac{k}{16m}}$

3. The electric field $\vec{E}_1$ at one face of a parallelopiped is uniform over the entire face and is directed out of the face. At the opposite face, the electric field $\vec{E}_2$ is also uniform over the entire face and is directed into that face as shown in figure. The two faces are inclined at 30° from the horizontal. $\vec{E}_1$ and $\vec{E}_2$ (both horizontal) have magnitudes of 2.50×10^4 N C^{-1} and 7.00×10^4 N C^{-1}, respectively. Assuming that no other electric field lines cross the surfaces of the parallelopipe, the net charge contained within is

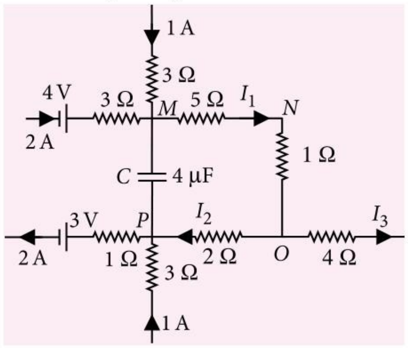


(a) $-67.5\varepsilon_0$ C (b) $37.5\varepsilon_0$ C
(c) $105\varepsilon_0$ C (d) $-105\varepsilon_0$ C

4. A thick rubber rope of density ρ and length L is suspended from a rigid support. If Y is the Young's modulus of elasticity of the material of the rope, then the increase in length of the rope due to its own weight is

(a) $\dfrac{1}{2}\rho gL^2Y$ (b) $\dfrac{\rho gL^2}{2Y}$ (c) $\dfrac{\rho gL}{Y}$ (d) $\dfrac{\rho gL}{6Y}$

5. A part of a circuit in steady state along with the current flowing in the branches. Value of each resistance is shown in figure. Calculate the energy stored in the 4 μF capacitor.



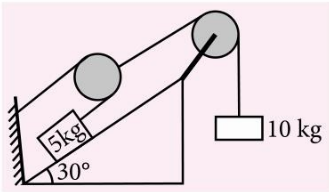
(a) 4×10^{-3} J (b) 6×10^{-4} J
(c) 8×10^{-4} J (d) 3×10^{-3} J

6. Given that $\ln(\alpha/P\beta) = \alpha z/k_B\theta$ where P is pressure, z is distance, k_B is Boltzmann constant and θ is temperature. The dimensions of β are

(a) $[M^0L^0T^0]$ (b) $[M^{-1}L^1T^{-2}]$
(c) $[M^0L^2T^0]$ (d) $[M^1L^{-1}T^{-2}]$

7. In the given figure, a mass 5 kg slides without friction on an inclined plane making an angle 30° with the horizontal. If this mass is connected to another mass of 10 kg through massless and frictionless

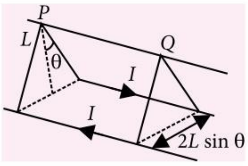
pulleys, then what is the acceleration of this mass when it is moving upwards is
(Take $g = 10$ m s^{-2}.)



(a) 0.33 m s^{-2}
(b) 3.3 m s^{-2}
(c) 33 m s^{-2}
(d) 3.03 m s^{-2}

8. Three closed vessels A, B and C are at the same temperature T and contain gases which obey the Maxwell distribution of speed. Vessel A contains only O_2, B only N_2 and C a mixture of equal quantities of O_2 and N_2. If the average speed of O_2 molecules in vessel A is v_1 and that of the N_2 molecules in vessels B is v_2, then average speed of the O_2 molecules in vessel C will be
(a) $(v_1 + v_2)/2$ (b) v_1
(c) $(v_1 v_2)^{1/2}$ (d) $\frac{v_1}{2}$

9. Two long parallel wires carry currents of equal magnitude but in opposite directions. These wires are suspended from rod PQ by four chords of same length L as shown in the figure. The mass per unit length of the wire is λ. Determine the value of θ assuming it to be small.



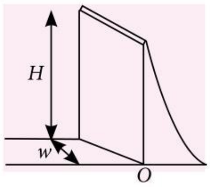
(a) $I\sqrt{\frac{\mu_0}{4\pi\lambda g L}}$ (b) $I\sqrt{\frac{4\pi\lambda g L}{\mu_0}}$
(c) $I\sqrt{\frac{\mu_0}{2\pi\lambda g}}$ (d) $2\pi\lambda\sqrt{\frac{\mu_0}{g}}I$

10. A monochromatic light of wavelength λ is incident on an isolated sphere of radius r. The threshold wavelength of the metal sphere is λ_0 (> λ). The number of photoelectrons emitted before the emission of photoelectrons stop is
(a) $\frac{4\pi\varepsilon_0 rh}{ce^2}\left[\frac{1}{\lambda}-\frac{1}{\lambda_0}\right]$ (b) $\frac{4\pi\varepsilon_0 h}{rce^2}\left[\frac{1}{\lambda}-\frac{1}{\lambda_0}\right]$
(c) $\frac{4\pi\varepsilon_0 rhc}{e^2}\left[\frac{1}{\lambda}-\frac{1}{\lambda_0}\right]$ (d) $\frac{2\pi\varepsilon_0 rhc}{e^2}\left[\frac{1}{\lambda}-\frac{1}{\lambda_0}\right]$

11. A bar measured with a Vernier caliper is found to be 180 mm long. The temperature during the measurement is 10 °C. What will be the error in measurement if the scale of the Vernier caliper has been graduated at a temperature of 20°C? ($\alpha = 1.1 \times 10^{-5}$ °C^{-1}). Assume that the length of the bar does not change.)
(a) 1.98×10^{-1} mm (b) 1.98×10^{-2} mm
(c) 1.98×10^{-3} mm (d) 1.98×10^{-4} mm

12. From a disc of radius a, an isosceles right angled triangle with the hypotenuse as the diameter of the disc is removed. The distance of the centre of mass of the remaining portion from the centre of the disc is
(a) $3(\pi - 1)a$ (b) $\frac{(\pi-1)a}{6}$
(c) $\frac{a}{3(\pi-1)}$ (d) $\frac{a}{3(\pi+1)}$

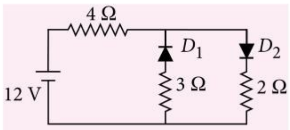
13. Water is filled to a height H behind a dam of width w as shown in figure. Determine the resultant force exerted by the water on the dam. Density of water is ρ.



(a) $\rho g H w^2$ (b) $\rho g w H^2$
(c) $\frac{1}{3}\rho g H^2 w$ (d) $\frac{1}{2}\rho g w H^2$

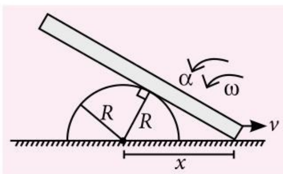
14. Consider two deuterons moving towards each other with equal speeds in a deutron gas. The closest separation between them becomes 2 fm? Assume that the nuclear force is not effective for separations greater than 2 fm. At what temperature will the deuterons have this speed on an average?
(a) 7.3×10^8 K (b) 3.4×10^9 K
(c) 2.8×10^9 K (d) 5.9×10^8 K

15. The circuit has two oppositely connected ideal diodes in parallel. What is the current flowing in the circuit?



(a) 2.31 A (b) 1.33 A (c) 1.71 A (d) 2.00 A

16. A rod leans against a stationary cylindrical body as shown in the figure. Now, its right end slides to the right on the floor with a constant speed v. Choose the correct option.

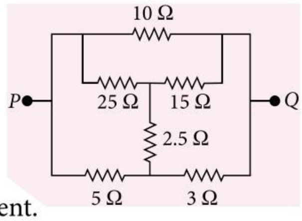


(a) The angular acceleration α is $-2Rv^2(2x^2 - R^2)/[x^2(x^2 - R^2)^{3/2}]$.
(b) The angular speed ω is $2Rv/[x(x^2 - R^2)^{1/2}]$.
(c) The angular speed ω is $Rv/[x(x^2 - R^2)^{1/2}]$.
(d) The angular acceleration α is $-Rv^2/[(x^2 - R^2)^{3/2}]$.

17. Two cars are moving along two straight tracks on the ground with the same speed 20 m s^{-1}. The angle between two tracks is $\frac{\pi}{3}$ rad and their intersection point is O. At a certain moment, the cars are at distance 300 m and 400 m from O. If they are moving towards O, then find minimum distance between them. (Take, $\sqrt{3} = 1.73$)

(a) 73.4 m (b) 86.5 m (c) 48.6 m (d) 32.9 m

18. If a battery of emf 8 V and negligible internal resistance is connected between terminals P and Q of the circuit shown in figure. Then mark the correct statement.



(a) The equivalent resistance of the circuit is 3 Ω.
(b) The current through 2.5 Ω resistance is 1A.
(c) The current drawn from the battery is 2A.
(d) The current drawn from 10 Ω resistance is zero.

19. A long narrow horizontal slit lies 1 mm above a plane mirror. The interference pattern produced by the slit and its image is viewed on a screen placed at a distance 1 m from the slit. The wavelength of light is 600 nm. Then the distance of the first maxima above the mirror is equal to

(a) 0.30 mm (b) 0.15 mm
(c) 60 mm (d) 7.5 mm

20. The de Broglie wavelength of a neutron corresponding to root mean square speed at 927 °C is λ. What will be the de Broglie wavelength of the neutron corresponding to root mean square speed at 27 °C?

(a) $\frac{\lambda}{2}$ (b) λ (c) 2λ (d) 4λ

21. A well lagged wire of length L and cross-sectional area A has its ends maintained at temperatures T_1 and T_2. The thermal conductivity of the wire is given by $K = B + CT$, where T is the temperature and B and C are constants. Choose the correct option regarding the rate of flow of heat $\frac{dQ}{dt}$ along the wire.

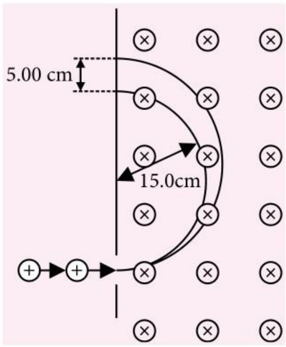
(a) If $C = 0$, $\frac{dQ}{dt} = \frac{AB}{L}(T_1 - T_2)$

(b) If $C = 0$, $B = 0$, $\frac{dQ}{dt} = \frac{A}{2L}(T_1 + T_2)$

(c) If $B = 0$, $\frac{dQ}{dt} = \frac{A}{2L}(T_1^2 + T_2^2)$

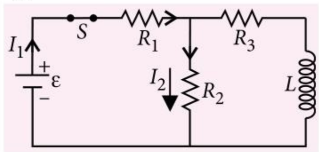
(d) If $C = B \neq 0$, $\frac{dQ}{dt} = \frac{AB}{L}(T_1^2 - T_2^2)$

22. A beam of singly ionised atoms of carbon (each charge $+e$) all have the same speed and enter a mass spectrometer, as shown in figure. The ions strike the photographic plate in two different locations 5.00 cm apart. The $^{12}C_6$ isotope traces a path of smaller radius, 15.0 cm. What is the mass number of other isotope?



(a) 12 (b) 13 (c) 15 (d) 14

23. In the circuit shown in figure, $\varepsilon = 100$ V, $R_1 = 10.0\ \Omega$, $R_2 = 20.0\ \Omega$, $R_3 = 30.0\ \Omega$ and $L = 2.00$ H. The values of I_1 and I_2,



(a) immediately after closing of switch S are 3.33 A and 2.73 A respectively.
(b) a long time after closing the switch are 4.55 A and 1.82 A.
(c) immediately after reopening the switch are 0 and 1.82 A.
(d) a long time after reopening the switch are 1.82 A and 3.33 A.

24. An unpolarised beam of light is incident on a group of four polarising sheets which are arranged in such a way that the characteristic direction of each polarising sheet makes an angle of 30° with of the preceding sheet. The percentage of incident light transmitted by third polariser will be

(a) 100% (b) 37.5% (c) 28% (d) 12.5%

25. Consider telecommunication through optical fibres. Which of the following statements is not true?

(a) Optical fibres may have homogeneous core with a suitable cladding.
(b) Optical fibres can be of graded refractive index.
(c) Optical fibres are subject to electromagnetic interference from outside.
(d) Optical fibres have extremely low transmission loss.

26. A uniform rope of length 12 m and mass 6 kg, is swinging vertically from rigid base. From its free end, one 2 kg mass is attached. At its bottom end

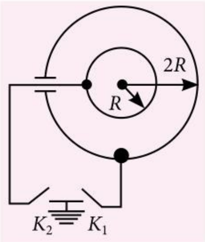
one transverse wave is produced of wavelength 0.06 m. At upper end of rope, wavelength will be

(a) 1.2 m (b) 0.12 m
(c) 9.12 cm (d) 0.12 mm

27. An amount of heat Q is supplied to one mole of a diatomic gas undergoing a process such that the volume $V = \dfrac{\alpha}{T^2}$, where T is the absolute temperature and α is a positive constant. If the temperature increases from T_0 to $3T_0$, then find Q.

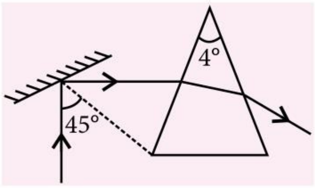
(a) $2RT_0$ (b) $4RT_0$ (c) $5RT_0$ (d) RT_0

28. Two concentric shells of radii R and $2R$ are shown in figure. Initially a charge q is imparted to the inner shell. Now key K_1 is closed and opened and then key K_2 is closed and opened. After the keys K_1 and K_2 are alternately closed n times each, find the potential difference between the shells. Note that finally the key K_2 remains closed.



(a) $-q/4\pi\varepsilon_0 2^{n+1}$ (b) $q/2\pi\varepsilon_0 2^n R$
(c) $-q/4\pi\varepsilon_0 R$ (d) zero

29. A ray of light strikes a plane mirror at an angle of incidence 45° as shown in the figure. After reflection, the ray passes through a prism of refractive index 1.50, whose apex angle is 4°. The angle through which the mirror should be rotated if the total deviation of the ray is to be 90° is



(a) 1° clockwise (b) 1° anticlockwise
(c) 2° clockwise (d) 2° anticlockwise.

30. Two nucleons are at a separation of 1 fm. The net force between them is F_1 if both are neutrons, F_2 if both are protons, and F_3 if one is a proton and the other is neutron. Choose the correct option.

(a) $F_1 > F_2 > F_3$ (b) $F_2 > F_1 > F_3$
(c) $F_1 = F_3 > F_2$ (d) $F_1 = F_2 > F_3$

SOLUTIONS

1. **(b):** Initial potential energy $= -\dfrac{GMm}{R+2000}$, where R is the radius of earth.

Initial kinetic energy $= \dfrac{1}{2}mv^2$,

where v is the velocity required to throw the man out.

Applying the law of conservation of energy

For a body to escape from earth, the total energy (PE + KE) should be equal to zero

Accordingly, $\dfrac{1}{2}mv^2 + \left(-\dfrac{GMm}{R+2000}\right) = 0$

$$\Rightarrow \quad v = \sqrt{\frac{2GM}{R+2000}}$$

2. **(a):** If l is the stretched length of the spring, then from figure $PB = d$ and $PA = l$

$$\frac{d}{l} = \cos 37° = \frac{4}{5}, \ \textit{i.e.}, \ l = \frac{5}{4}d$$

So, the stretch $y = l - d = \dfrac{5}{4}d - d = \dfrac{d}{4}$

and $AB = h = l \sin 37° = \dfrac{5}{4}d \times \dfrac{3}{5} = \dfrac{3}{4}d$

Now, taking point B as reference level and applying law of conservation of mechanical energy between A and B,

$$mgh + \frac{1}{2}ky^2 = \frac{1}{2}mv^2$$

or $\dfrac{3}{4}mgd + \dfrac{1}{2}k\left(\dfrac{d}{4}\right)^2 = \dfrac{1}{2}mv^2$

or $v = d\sqrt{\dfrac{3g}{2d} + \dfrac{k}{16m}}$

3. **(a):** To find the charge enclosed, we need to find the flux through the parallelopipe.

$\phi_1 = AE_1 \cos 60°$
$= (0.05 \text{ m}) (0.06 \text{ m}) (2.50 \times 10^4 \text{ N C}^{-1}) \cos 60°$
$= 37.5 \text{ N m}^2 \text{ C}^{-1}$

$\phi_2 = AE_2 \cos 120°$
$= (0.05 \text{ m}) (0.06 \text{ m}) (7.00 \times 10^4 \text{ N C}^{-1}) \cos 120°$
$= -105 \text{ N m}^2 \text{ C}^{-1}$

So, the total flux is

$\phi = \phi_1 + \phi_2 = (37.5 - 105) \text{ N m}^2 \text{ C}^{-1} = -67.5 \text{ N m}^2 \text{ C}^{-1}$

Net charge enclosed, $q = \phi\varepsilon_0 = -67.5\ \varepsilon_0 \text{ C}$

There must be a net charge (negative) in the parallelepiped since there is a net flux flowing into the surface. Also, there must be an external field, otherwise all lines would point toward the slab.

4. **(b):** Since the weight acts at centre of mass, $L_{eq} = \dfrac{L}{2}$ and $F = mg$

If x is the extension produced,

$$Y = \frac{F \cdot L_{eq}}{Ax} \text{ or } x = \frac{F \cdot (L/2)}{A \cdot Y} = \frac{(\rho LAg)L}{A \cdot Y \cdot 2}$$

$$\Rightarrow \quad x = \frac{\rho \cdot gL^2}{2Y}$$

5. **(c) :** Applying Kirchhoff's first law at junction M, we get the current $I_1 = 3$ A. Applying Kirchhoff's first law at junction P, we get the current $I_2 = 1$ A. For loop $MNOP$, we get

$V_M - 5I_1 - I_1 - 2I_2 = V_P$ or $V_M - V_P = 6I_1 + 2I_2 = 20$ V

Energy stored in the capacitor is

$$\frac{1}{2}CV^2 = \frac{1}{2} \times 4 \times 10^{-6} \times 20 \times 20 = 8 \times 10^{-4}\,\text{J}$$

6. **(c) :** $\ln\left(\frac{\alpha}{P\beta}\right) = \frac{\alpha z}{k_B\theta}$

$[\alpha z] = [k_B\theta]$ and $[\alpha] = [P\beta]$

$$[\beta] = \frac{[k_B\theta]}{[Pz]} = \frac{[\text{ML}^2\text{T}^{-2}][\text{K}^{-1}][\text{K}]}{[\text{ML}^{-1}\text{T}^{-2}][\text{L}]} = \text{L}^2$$

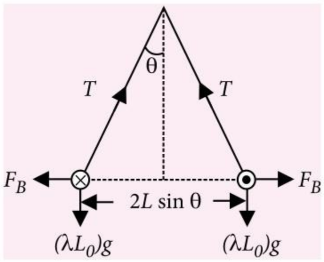
7. **(b)**

8. **(b):** $v_{av} = \sqrt{\frac{8RT}{\pi M_0}}$, $v_{av} \propto \sqrt{T}$

For same temperature in vessel A, B and C, average speed of O_2 molecule is same in vessel A and C and is equal to v_1.

9. **(a) :** The force per unit length between current carrying parallel wires is

$$\frac{dF}{dL} = \frac{\mu_0 I_1 I_2}{2\pi d}$$



If two wires carry current in opposite directions the magnetic force is repulsive, due to which the parallel wires have moved out so that equilibrium is reached. Figure shows free body diagram of each wire. In equilibrium,

$\Sigma F_y = 0$, $2T\cos\theta = (\lambda L_0)\,g$ (i)

$\Sigma F_z = 0$, $2T\sin\theta = F_B$ (ii)

Now dividing eqn. (ii) by eqn. (i) we get

$$\tan\theta = \frac{F_B}{L_0\lambda g}$$

where, the magnetic force,

$$F_B = \left(\frac{dF}{dL}\right) \times L_0 = \frac{\mu_0 I^2}{4\pi\sin\theta}\frac{L_0}{L}$$

For small θ, $\tan\theta \simeq \sin\theta \simeq \theta$

$$\therefore\ \theta = I\sqrt{\frac{\mu_0}{4\pi\lambda g L}}$$

10. **(c) :** As the sphere is isolated, therefore on emission of photoelectrons from sphere, the potential of sphere is raised. Let the emission of photoelectrons be stopped when the potential of sphere becomes V. Therefore,

$$eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \quad \text{or} \quad V = \frac{hc}{e}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$

Charge on sphere, $Q = (4\pi\varepsilon_0 r)V$

Number of photoelectrons emitted,

$$n = \frac{Q}{e} = \frac{(4\pi\varepsilon_0 r)V}{e} = \frac{(4\pi\varepsilon_0 rhc)}{e^2}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$

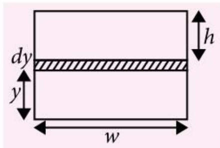
11. **(b):** True measurement = scale reading $[1 + \alpha(\theta - \theta_0)]$

$= 180\,[1 - 10 \times 1.1 \times 10^{-5}]$

Error $= 180 - 180\,[1 - 1.1 \times 10^{-4}] = 1.98 \times 10^{-2}$ mm

12. **(c)**

13. **(d) :** Let's consider a vertical y axis, starting from the bottom of the dam. Let's consider a thin horizontal strip at a height y above the bottom. We need to consider force due to the pressure of the water only as atmospheric pressure acts on both sides of the dam.



The pressure due to the water at the depth h

$P = \rho g h = \rho g(H - y)$

The force exerted on the shaded strip of area $dA = w dy$,

$dF = P\,dA = \rho g(H - y)\,w\,dy$

Integrate to find the total force on the dam

$$F = \int P\,dA = \int_0^H \rho g\,(H - y)\,w\,dy = \frac{1}{2}\rho g w H^2$$

14. **(c) :** As the deuterons move, the Coulombic repulsion will slow them down. The loss in kinetic energy will be equal to the gain in Coulombic potential energy. At the closest separation, the kinetic energy is zero and the potential energy is $\frac{e^2}{4\pi\varepsilon_0 r}$. If the initial kinetic energy of each deuteron is K and the closet separation is 2 fm, we shall have

$$2K = \frac{e^2}{4\pi\varepsilon_0(2\text{ fm})}$$

$$= \frac{(1.6 \times 10^{-19}\,\text{C})^2 \times (9 \times 10^9\,\text{N m}^2\,\text{C}^{-2})}{2 \times 10^{-15}\,\text{m}}$$

or $K = 5.7 \times 10^{-14}$ J

If the temperature of the gas is T, the average kinetic energy of random motion of each nucleus will be $1.5\,k_BT$. The temperature needed for the deuterons to have the average kinetic energy of 5.7×10^{-14} J will be given by

$1.5\, k_B T = 5.7 \times 10^{-14}$ J
where k_B = Botzmann's constant

or, $T = \dfrac{5.7\times 10^{-14}\,\text{J}}{1.5\times 1.38\times 10^{-23}\ \text{J K}^{-1}} = 2.8 \times 10^9$ K.

15. (d)

16. (c) : From geometry,

$$x = \frac{R}{\sin\theta}$$

$$\therefore \quad v = \frac{dx}{dt} = \frac{d}{dt}\left(\frac{R}{\sin\theta}\right) = \frac{R(d\theta/dt)(-\cos\theta)}{\sin^2\theta}$$

$$\omega = -\frac{d\theta}{dt}$$

so $\quad v = \dfrac{\omega R\cos\theta}{\sin^2\theta}$

$$\because\ \omega = \frac{v\sin^2\theta}{R\cos\theta} = \frac{v}{R}\cdot\frac{(R/x)^2}{\left(\left(\sqrt{x^2-R^2}\right)/x\right)} = \frac{Rv}{x(x^2-R^2)^{1/2}}$$

$$\alpha = \frac{d\omega}{dt} = \frac{d}{dt}\left[\frac{Rv}{x\sqrt{x^2-R^2}}\right] = -\frac{Rv^2\,(2x^2-R^2)}{x^2(x^2-R^2)^{3/2}}$$

17. (b): Here OA = 300 m, OB = 400 m, $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$

$$\therefore \quad \tan\theta = \frac{v_B\sin 120^\circ}{v_A + v_B\cos 120^\circ} = \frac{20\sqrt{3/2}}{20-20\times\frac{1}{2}} = \sqrt{3}$$

$\therefore \quad \theta = 60^\circ$

By geometry,

$\therefore \quad OD = OA = 300$ m

$\therefore \quad DB = 400 - 300$

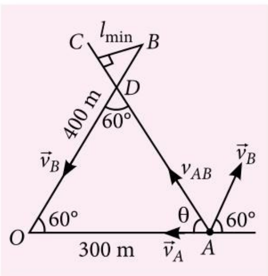
$= 100$ m

$\therefore \quad l_{\min} = DB \sin 60^\circ$

$= 100 \times \dfrac{\sqrt{3}}{2}$

$= 50\sqrt{3}$ m

$= 86.5$ m



18. (c) : Since the bridge is balanced, hence current through 2.5 Ω resistance is zero.

Current through 10 Ω resistance is $\dfrac{8}{10}\text{A} = 0.8\,\text{A}$

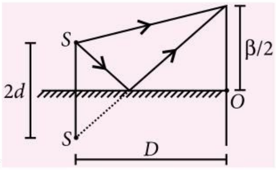
$\therefore$ Equivalent resistance is given by

$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{25+15} + \frac{1}{5+3} = \frac{1}{10} + \frac{1}{40} + \frac{1}{8} = \frac{1}{4}$$

or $\quad R_{eq} = 4\ \Omega$

$\therefore$ Current drawn from battery is (8/4) A = 2 A.

19. (b): Point O is a minima. Hence the first maxima will be at $y = \dfrac{\beta}{2}$ from O.



$$\Rightarrow \quad y = \frac{\lambda D}{2(2d)}$$

$$= \frac{600\times 10^{-9}\times 1}{4\times 1\times 10^{-3}}\,\text{m}$$

$= 0.15$ mm.

20. (c) : Kinetic energy of neutron $E = \dfrac{3}{2}k_B T$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m\times\frac{3}{2}k_B T}} \Rightarrow \lambda \propto \frac{1}{\sqrt{T}}$$

$$\lambda_2 = \lambda\cdot\sqrt{\frac{(927+273)}{27+273}} = 2\lambda$$

21. (a) : The rate at which heat is flowing through the wire is given by the definition of thermal conductivity as

$$\frac{dQ}{dt} = -KA\frac{dT}{dx}.$$

Since the wire is well lagged, we may assume that no heat enters or leaves it except at the ends, so dQ/dt must be constant.

Let a constant $D = \dfrac{1}{A}\dfrac{dQ}{dt}$,

$$\therefore \quad (B + CT)\frac{dT}{dx} = -D. \qquad (\text{As } K = B + CT)$$

This differential equation can be solved by rearranging and integrating

$$\int_{T_1}^{T_2}(B + CT)\,dT = -D\int_0^L dx.$$

This gives, $B(T_2 - T_1) + \dfrac{C}{2}(T_2^2 - T_1^2) = -DL.$

So, $\dfrac{dQ}{dt} = AD = \dfrac{A}{L}\left(B(T_1 - T_2) + \dfrac{C}{2}\left(T_1^2 - T_2^2\right)\right).$

or $\quad \dfrac{dQ}{dt} = \dfrac{A}{L}(T_1 - T_2)\left(B + \dfrac{C}{2}(T_1 + T_2)\right).$

22. (d): Let R_1 be the radius of trajectory of the isotope $^{12}C_6$ and R_2 that of the unknown isotope. The trajectory of the unknown isotope has a greater radius, and so the mass of the unknown isotope is greater than that of the $^{12}C_6$ isotope.

$2R_2 - 2R_1 = 5.00 \times 10^{-12}$ m

$R_2 - R_1 = 2.5 \times 10^{-12}$ m

Since $R_1 = 15.0 \times 10^{-2}$ m

$R_2 = 15.0 \times 10^{-2}$ m + 2.50×10^{-2} m = 17.5×10^{-2} m

For each isotope, $R_1 = \frac{m_1 v}{Bq}$, $R_2 = \frac{m_2 v}{Bq}$

$\therefore \quad \frac{R_2}{R_1} = \frac{m_2}{m_1}$

Since, $m_1 = \alpha(12)$, $m_2 = \alpha A$

where A is mass number of unknown isotope and α is a constant.

So, $\frac{R_2}{R_1} = \frac{m_2}{m_1} = \frac{A}{12} \quad \therefore \quad \frac{17.5 \times 10^{-12}\,\text{m}}{15.0 \times 10^{-12}\,\text{m}} = \frac{A}{12}$

Solving for unknown atomic mass number, we obtain $A = 14$. Thus the unknown isotope is ${}^{14}C_6$.

23. (c) : Immediately after closing the switch, the inductor opposes the fast build up of the current through it and hence current in the inductor is zero.

This means $I_1 = I_2 = \frac{\varepsilon}{R_1 + R_2} = \frac{100}{10 + 20} = 3.33\,\text{A}$

A long time after the current reaches its steady state value, the emf across the inductor is zero, the inductor behaves as if it were replaced by a wire (*i.e.*, short-circuited).

$$I_1 = \frac{\varepsilon(R_2 + R_3)}{R_1R_2 + R_1R_3 + R_2R_3}$$

$$= \frac{(100)\,(20 + 30)}{(10)(20) + (10)(30) + (20)\,(30)} = 4.55\text{ A}$$

and $I_2 = \frac{\varepsilon R_3}{R_1R_2 + R_1R_3 + R_2R_3}$

$$= \frac{(100)(3)}{(10)(20) + (10)(30) + (20)(30)} = 2.73\,\text{A}$$

When the switch is reopened, the left loop is an open circuit. The current immediately drops to zero when the switch is opened; hence $I_1 = 0$. The current in R_3 *i.e.*, 4.55A – 2.73 A = 1.82 A which changes only slowly because there is an inductor in its branch. . The current in R_2 is the same as that in R_3, 1.82 A.

In the absence of any source of emf all the currents drop to zero.

24. (c) **25. (c)**

26. (b): Tension at bottom end of rope $T_1 = 2 \times 9.8$ N

$\because$ weight of rope acts on centre of gravity

Therefore, tension at upper end of rope,

$T_2 = (6 + 2) \times 9.8 = 8 \times 9.8$ N

Thus, $T_2 = 4T_1$

If v_1 and v_2 are respective velocity at bottom and upper end, then $v_1 = \sqrt{\frac{T_1}{\mu}}$ and $v_2 = \sqrt{\frac{T_2}{\mu}}$

$\therefore \quad v_2 = 2v_1 \quad (\because T_2 = 4T_1)$

Frequency of wave does not depend on medium, therefore $v \propto \lambda$

If λ_1 and λ_2 are respective wavelength at bottom and upper end or rope, then

$\lambda_2 = 2\lambda_1 = 2 \times 0.06 = 0.12$ m

27. (d): From the first law of thermodynamics,

$$Q = \Delta U + W = \Delta U + \int P dV \quad \text{...(i)}$$

Here, $\Delta U = nC_V \Delta T = 1 \cdot \frac{R}{\gamma - 1}(3T_0 - T_0)$

$$= \frac{2RT_0}{(7/5) - 1} = 5RT_0$$

Now, work done by the gas,

$W = \int P dV = \int \frac{RT}{V} dV \quad [\because PV = RT \text{ for 1 mole}].$

Given, $V = \frac{\alpha}{T^2}$ or $dV = -2\frac{\alpha}{T^3}\,dT.$

Substituting V and dV and integrating under the given limits, we get

$$W = \int_{T_0}^{3T_0} \frac{RT}{\left(\frac{\alpha}{T^2}\right)}\left(-\frac{2\alpha}{T^3}\,dT\right) = \int_{T_0}^{3T_0} \frac{-2\alpha RT^3}{\alpha T^3}\,dT$$

$$= -2R\int_{T_0}^{3T_0} dT = -2R(3T_0 - T_0) = -4RT_0.$$

Substituting the values of ΔU and W in equation (i), we get $Q = 5RT_0 - 4RT_0 = RT_0$.

28. (a)

29. (b) : Deviation by prism = $A(\mu - 1) = 4°(1.5 - 1) = 2°$

For 90° total deviation,

Deviation by mirror = 90 ° – 2° = 88°

$\therefore \quad 180° - 2i = 88°$

$2i = 92°$ or $i = 46°$

Mirror should be rotated 1° anticlockwise.

30. (c) : Nuclear force of attraction between any two nucleons (n - n, p - p; p - n) is same. The difference comes up only due to electrostatic force of repulsion between two protons.

$\therefore \quad F_1 = F_3 \neq F_2$. As $F_2 < F_3$ or F_1

$\therefore \quad F_1 = F_3 > F_2$

PRACTICE PAPER

NEET

Exam on
6^{th} May 2018

1. One mole of helium gas, initially at STP (P_1 = 1 atm = 101.3 kPa, T_1 = 0 °C = 273.15 K), undergoes an isovolumetric process in which its pressure falls to half its initial value. The helium gas then expands isobarically to twice its volume what is the work done by the gas?
(a) 1135 J (b) 1535 J
(c) 2335 J (d) 3335 J

2. Twelve wires of equal resistance R are connected to form a cube. The effective resistance between two opposite diagonal ends will be
(a) (5/6) R (b) (6/5) R
(c) 3 R (d) 12 R

3. The force between two charges situated in air is F. The force between the same charges if the distance between them is reduced to half and they are situated in a medium having dielectric constant 4 is
(a) $F/4$ (b) 4 F (c) 16 F (d) F

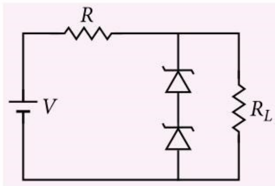
4. If ρ is mean density of earth, r its radius, g the acceleration due to gravity and G, the gravitational constant, on the basis of dimensional consistency, the correct expression is
(a) $\rho = \frac{3G}{4\pi r g}$ (b) $\rho = \frac{rG}{12\pi g}$
(c) $\rho = \frac{3g}{4\pi r G}$ (d) $\rho = \frac{3r}{4\pi g G}$

5. A crate of mass 50 kg slides down a 30° incline. The crate's acceleration is 2.0 m s^{-2}, and the incline is 10 m long. What is the magnitude of the frictional force that acts on the crate as it slides down the incline?
(a) 245 N (b) 345 N (c) 145 N (d) 445 N

6. Large number of capacitors of rating 10 μF-200 V are available. The minimum number of capacitors required to design a 10 μF-800 V capacitor is
(a) 16 (b) 4 (c) 8 (d) 7

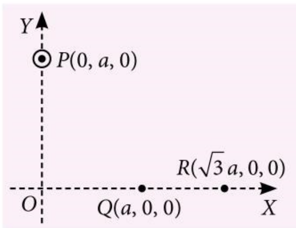
7. A block of mass 4 kg hangs from a spring of force constant k = 400 N m^{-1}. The block is pulled down 15 cm below equilibrium and released. Find the kinetic energy when the block is 10 cm above equilibrium.
(a) 1.5 J (b) 2.5 J
(c) 3.5 J (d) 4.5 J

8. In figure, two Zener diodes are connected in series in a voltage regulator circuit. The maximum current through each of the diodes is 250 mA and the Zener voltage is 20 V. Calculate the resistance R for V = 50 V.



(a) 10 Ω
(b) 80 Ω
(c) 20 Ω
(d) 40 Ω

9. One end of an infinitely long straight wire carrying a steady current I in the positive direction of the Z-axis is situated at the point $P(0, a, 0)$, as shown in figure. Find $\int \vec{B} \cdot d\vec{l}$ along the line joining the points Q and R.



(a) $\frac{\mu_0 I}{24}$ (b) $\frac{\mu_0 I}{48}$
(c) $\frac{\mu_0 I}{12}$ (d) $\frac{\mu_0 I}{21}$

10. Two boys start running straight toward each other from two points that are 100 m apart. One runs with a speed of 5 m s^{-1}, while the other moves as 7 m s^{-1}. How close are they to the slower one's starting point when they meet each other?
(a) 41.7 m (b) 42.8 m (c) 45.9 m (d) 46.1 m

11. A coil of inductance 0.50 H and resistance 100 Ω is connected to a 240 V, 50 Hz a.c. supply. Calculate time lag between current and voltage.
(a) 3.2 ms (b) 5.2 ms (c) 7.2 ms (d) 9.2 ms

12. Binding energy of nuclei P, Q and R are E_P, E_Q and E_R respectively. In the fusion processes
$3P \rightarrow Q$ + Energy (E_1)
$2Q \rightarrow R$ + Energy (E_2)
Calculate, total energy (E_3) released in the fusion process $6P \rightarrow R$ + Energy (E_3).
(a) $E_1 + E_2$ (b) $E_1 - E_2$
(c) $E_1 - 2E_2$ (d) $2E_1 + E_2$

13. An object producing a pitch of 400 Hz flies past a stationary person. The object was moving in a straight line with a velocity 200 m s^{-1}. What is the change in frequency noted by the person as the object flies past him? (Speed of sound in air = 300 m s^{-1})
(a) 1200 Hz (b) 960 Hz
(c) 240 Hz (d) 1440 Hz

14. The ratio of the KE required to be given to the satellite to escape earth's gravitational field to the KE required to be given so that the satellite moves in a circular orbit just above earth's atmosphere is
(a) 1 (b) 1/2 (c) 2 (d) infinity

15. Light of frequency 7.21×10^{14} Hz is incident on a metal surface. The maximum speed of the photoelectrons emitted is 6.0×10^5 m s^{-1}. What is the threshold frequency for the photoemission of electrons?
(a) 4.73×10^{14} Hz (b) 7.31×10^{14} Hz
(c) 4.73×10^{15} Hz (d) 7.34×10^{15} Hz

16. Find the mass of the block that a 40 hp engine can pull along a level road at 15 m s^{-1} if the coefficient of friction between block and road is 0.15.
(a) 2532 kg (b) 1353 kg
(c) 3553 kg (d) 4553 kg

17. A hole of area 1 mm^2 opens in the pipe near the lower end of a large water-storage tank, and a stream of water shoots from it. If the top of the water in the tank is 20 m above the point of the leak, how much water escapes in 1s?
(a) 19.8 mL s^{-1} (b) 28.8 mL s^{-1}
(c) 38.8 mL s^{-1} (d) 48.8 mL s^{-1}

18. In a Young's double-slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where the path difference is λ, is K units. What is the intensity of light at a point where the path difference is $\lambda/3$?
(a) $\frac{K}{4}$ (b) $\frac{K}{2}$ (c) $\frac{K}{6}$ (d) $\frac{K}{8}$

19. A satellite sent into space samples the density of matter within the solar system and gets a value of 2.5 hydrogen atoms per cubic centimeter. What is the mean free path of the hydrogen atoms? Take the diameter of a hydrogen atoms as d = 0.24 nm.
(a) 1.56×10^{12} m (b) 2.56×10^{12} m
(c) 3.56×10^{12} m (d) 4.56×10^{12} m

20. When two bar magnets have their like poles tied together, they make 12 oscillations per minute and when their unlike poles are tied together, they make 4 oscillations per minute. Find the ratio of their magnetic moments.
(a) $\frac{2}{3}$ (b) $\frac{3}{2}$ (c) $\frac{5}{4}$ (d) $\frac{4}{5}$

21. The amplitude of a damped oscillator becomes half in one minute. The amplitude after 3 minutes will be $(1/x)$ times the original, where x is
(a) 2×3 (b) 2^3
(c) 3^2 (d) 3×2^2

22. A 500 g wheel that has a moment of inertia of 0.015 kg m^2 is initially turning at 30 rps. It comes to rest after 163 revolution. How large is the torque that slowed it?
(a) −0.26 N m (b) −0.45 N m
(c) −0.55 N m (d) −0.95 N m

23. For a series resonant LCR circuit with L = 2 H, C = 32 μF and R = 10 Ω, what is the Q-factor of this circuit?
(a) 25 (b) 50 (c) 75 (d) 100

24. A bullet of mass m, moving with a speed of u penetrates a block of wood of thickness x and emerges with a speed v. The force of resistance offered by the wood is given by
(a) $\frac{m}{x}(u^2 - v^2)$ (b) $\frac{m}{2x}(u^2 - v^2)$
(c) $\frac{m}{2x}(v^2 - u^2)$ (d) $\frac{m}{x}(v^2 - u^2)$

25. A proton when accelerated through a potential difference of V volts has a wavelength λ associated with it. An α particle in order to have the same wavelength λ, must be accelerated through a potential difference (in volts)

(a) $2V$ (b) V (c) $\frac{V}{4}$ (d) $\frac{V}{8}$

26. A tank contains a pool of mercury 0.30 m deep, covered with a layer of water that is 1.2 m deep. The density of water is 1.0×10^3 kg m^{-3} and that of mercury is 13.6×10^3 kg m^{-3}. Find the pressure exerted by the double layer of liquids at the bottom of the tank. Ignore the pressure of the atmosphere.
(a) 52 kPa (b) 72 kPa (c) 82 kPa (d) 92 kPa

27. An open and closed organ pipe have the same length. The ratio of pth mode of frequency of vibration of two pipes is
(a) 1 (b) p
(c) $p(2p + 1)$ (d) $\frac{2p}{(2p-1)}$

28. The images of a small electric bulb fixed on the wall of a room is to be obtained on the opposite wall, 3 m away, by means of a large convex lens. What is the maximum possible focal length of the lens?
(a) 0.55 m (b) 0.65 m (c) 0.75 m (d) 0.85 m

29. A metallic rod of length 1.0 m is rotated with an angular frequency of 400 rad s^{-1} about an axis normal to the rod and passing through one end. The other end of the rod is in contact with a circular metallic ring. A constant and uniform magnetic field of 0.5 T and parallel to the axis exists around the rod and the ring. Calculate the emf developed between the centre and the ring.
(a) 220 V (b) 120 V
(c) 100 V (d) 200 V

30. A boy stands on a freely rotating platform. With his arms extended, his rotational speed is 0.25 rps. But when he draws them in, his speed is 0.80 rps. The ratio of his moment of inertia in the first case to that in the second case is
(a) 2.2 (b) 3.2 (c) 4.2 (d) 5.2

31. The dispersive powers of two thin prisms of refracting angles A and A' are 0.03 and 0.05 respectively. The refractive indices for yellow light for the prisms are 1.517 and 1.621 respectively. If the combination of prisms produces a deviation of 1° in the yellow light without producing any angular dispersion, then the values of A and A' respectively are
(a) 4.8°, 2.4° (b) 3.6°, 1.6°
(c) 3.3°, 1.3° (d) 2.2°, 1.2°

32. A parallel plate capacitor has circular plates of radius 6.0 cm each and a capacitance of 100 pF. It is connected to a 230 V a.c. supply with a frequency of 300 rad s^{-1}. Determine the amplitude of magnetic field at a point 3.0 cm from the axis between the plates.
(a) 5.6×10^{-10} T (b) 6.5×10^{-11} T
(c) 7.6×10^{-11} T (d) 7.6×10^{-10} T

33. A straight rod of length L extends from $x = a$ to $x = L + a$ with the mass per unit length $A + B\,x^2$. The gravitational force exerted by the rod on a point mass m at $x = 0$ is

(a) $Gm\left[A\left(\frac{1}{a+L}-\frac{1}{a}\right)+BL\right]$

(b) $Gm\left[A\left(\frac{1}{a}-\frac{1}{a+L}\right)+BL\right]$

(c) $Gm\left[A\left(\frac{1}{(a+L)}+\frac{1}{a}\right)-BL\right]$

(d) $Gm\left[A\left(\frac{1}{a}-\frac{1}{(a+L)}\right)-BL\right]$

34. A 400 g block originally moving at 120 cm s^{-1} travels 70 cm along a tabletop before coming to rest. What is the coefficient of friction between block and table?
(a) 0.105 (b) 0.305 (c) 0.405 (d) 0.505

35. A parallel beam of light of wavelength 550 nm is focused by a convex lens of diameter 10.0 cm on a screen at a distance of 25 cm from it. Find the diameter of the image of disc that is formed.
(a) 2.24×10^{-4} cm (b) 3.34×10^{-4} cm
(c) 4.44×10^{-4} cm (d) 5.44×10^{-4} cm

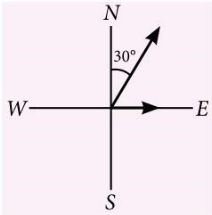
36. What is the maximum amount of work that a Carnot engine can perform per kcal of heat input if it absorbs heat at 427 °C and exhausts heat at 177 °C?
(a) 3.96 kJ (b) 1.49 kJ
(c) 5.96 kJ (d) 7.96 kJ

37. When a building is constructed at –10 °C, a steel beam (cross-sectional area 45 cm^2) is put in place with its ends cemented in pillars. If the sealed ends cannot move, what will be the compressional force in the beam when the temperature is 25 °C? For steel, Y = 200 000 MPa, and $\alpha_{steel} = 1.2 \times 10^{-5}$ °C.
(a) 380 kN (b) 480 kN
(c) 580 kN (d) 780 kN

38. The half-life of ${}^{90}_{38}\text{Sr}$ is 28 years. What is the disintegration rate of 15 mg of this isotope?
(a) 2.12 Ci (b) 3.12 Ci (c) 1.22 Ci (d) 2.81 Ci

39. An infinite number of electric charges each equal to 5 nC (magnitude) are placed along x-axis at $x = 1$ cm, $x = 2$ cm, $x = 4$ cm, $x = 8$ cm ... and so on. In the setup if the consecutive charges have opposite sign, then the electric field (in N C^{-1}) at $x = 0$ is
(a) 12×10^4 (b) 24×10^4
(c) 36×10^4 (d) 48×10^4

40. A ship is travelling due east at 10 km h^{-1}. What must be the speed of a second ship heading 30° east of north if it is always due north from the first ship?



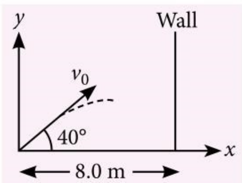
(a) 5 km h^{-1}
(b) 10 km h^{-1}
(c) 15 km h^{-1} (d) 20 km h^{-1}

41. A hydrogen sample in the ground state absorbs monochromatic radiation of wavelength λ and emits radiation of six different wavelengths. Find the value of λ.
(a) 1000 Å (b) 680 Å (c) 1200 Å (d) 975 Å

42. When 5 g of a certain type of coal is burned, it raises the temperature of 1000 mL of water from 10 °C to 47 °C. Calculate the heat energy produced per gram of coal. Given, heat capacity of water is 1 cal g^{-1} °C^{-1}. Neglect the small heat capacity of the coal.
(a) 8400 cal g^{-1} (b) 9400 cal g^{-1}
(c) 7400 cal g^{-1} (d) 6400 cal g^{-1}

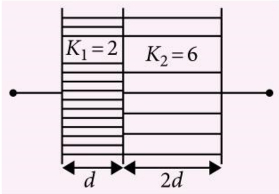
43. In a straight conductor of uniform cross-section charge q is flowing for time t. Let s be the specific charge of an electron. The momentum of all the free electrons per unit length of the conductor, due to their drift velocity only is
(a) q/ts (b) q/ts^2
(c) $\sqrt{(q/ts)}$ (d) qts

44. A hose lying on the ground shoots a stream of water upward at an angle of 40° to the horizontal. The speed of the water is 20 m s^{-1} as it leaves the hose. How high up will it strike a wall which is 8 m away?



sin40° = 0.64
(a) 2.33 m (b) 5.33 m (c) 8.33 m (d) 11.33 m

45. A parallel plate capacitor has two layers of dielectrics as shown in figure. This capacitor is connected across a battery, then the ratio of potential difference across the dielectric layers is



(a) 1/3
(b) 4/3
(c) 3/2
(d) 1/2

SOLUTIONS

1. (a) : $W = \int_{V_1}^{2V_1} \frac{1}{2} P_1 dV = \frac{1}{2} P_1 V_1 = \frac{1}{2} RT_1$
$= \frac{1}{2}(8.31)(273.15) = 1135 \text{ J}$

2. (a) : The effective resistance between two diagonally opposite ends = 5 R/6.

3. (d) : $F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$

$F' = \frac{q_1 q_2}{4\pi\varepsilon(r/2)^2} = \frac{4q_1 q_2}{4\pi\varepsilon r^2}$

$\frac{F'}{F} = 4\frac{\varepsilon_0}{\varepsilon} = 4\left(\frac{1}{K}\right) = 4\left(\frac{1}{4}\right) = 1 \quad \therefore \; F' = F$

4. (c) : $\frac{3g}{4\pi r G} = \frac{(LT^{-2})}{L(M^{-1}L^3T^{-2})} = [ML^{-3}] = \rho$

5. (c)

6. (a) : Number of capacitors to be connected in series
$= \frac{\text{voltage rating required}}{\text{voltage rating of given capacitor}} = \frac{800}{200} = 4$

$C_{eq} = \frac{10}{4} = 2.5\,\mu\text{F}$

Number of rows required
$= \frac{\text{Capacity required}}{\text{Capacity of each row}} = \frac{10}{2\cdot 5} = 4$

$\therefore$ Total number of capacitors required = 4 × 4 = 16

7. (b) : Given, $A = 0.15$ m; $k = 400$ N m^{-1}

(From conservation of mechanical energy.)

$\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$

$\frac{1}{2}mv^2 = \frac{1}{2}k(A^2 - x^2) = \frac{1}{2} \times 400(0.15^2 - 0.1^2) = 2.5 \text{ J}$

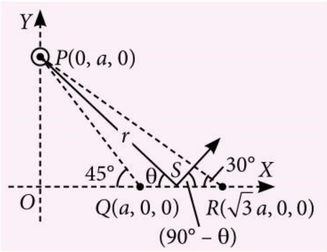
8. (d) : Since both the Zener diodes are in series, the voltage across $R_L = 2 \times 20$ V = 40 V.

From Kirchhoff's loop rule, the current in the Zener loop,

$$I = \frac{50\text{ V} - 40\text{ V}}{R} = \frac{10\text{ V}}{R}$$

$$\therefore 250\,\text{mA} = \frac{10\text{ V}}{R} \Rightarrow R = \frac{10\text{ V}}{250\text{ mA}} = \frac{10\text{ V}}{250\times10^{-3}\text{ A}} = 40\,\Omega$$

9. (a) : From figure, $\angle PQO = \pi/4$ and $\angle PRO = \pi/6$. Consider a point S on the x-axis lying between the points Q and R. Let $PS = r$. The magnetic



field $B = \dfrac{\mu_0 I}{2\pi r}$ is directed perpendicular to the line PS, as shown in the figure. The field $\vec{B}$ makes an angle $(90° - \theta)$ with the positive direction of the x-axis.

$$\therefore \quad \vec{B}\cdot d\vec{x} = Bdx\cdot\cos(90° - \theta) = \frac{\mu_0 I}{2\pi r}\cdot dx\cdot\sin\theta \qquad \text{...(i)}$$

Let $OS = x$. Then

$$\frac{OP}{OS} = \frac{a}{x} = \tan\theta \;\Rightarrow\; x = a\cot\theta.$$

Differentiating, $dx = -a\text{cosec}^2\theta\, d\theta$.

Similarly, $\dfrac{OP}{PS} = \dfrac{a}{r} = \sin\theta \;\Rightarrow\; \left(\dfrac{1}{r}\right) = \left(\dfrac{\sin\theta}{a}\right)$.

Substituting for dx and $\left(\dfrac{1}{r}\right)$ in eqn. (i) and integrating,

$$\int_Q^R \vec{B}\cdot d\vec{l} = \int_Q^R \vec{B}\cdot d\vec{x} = \int_Q^R \frac{\mu_0 I}{2\pi}\sin\theta\left(\frac{\sin\theta}{a}\right)(-a\text{cosec}^2\theta d\theta)$$

$$= -\frac{\mu_0 I}{2\pi}\int_{\pi/4}^{\pi/6} d\theta = \frac{\mu_0 I}{2\pi}\left[\frac{\pi}{4} - \frac{\pi}{6}\right] = \frac{\mu_0 I}{2\pi}\times\frac{\pi}{12} = \frac{\mu_0 I}{24}.$$

10. (a) : The two boys meet at the same place and time. The time for the slower one to travel a distance x is $x/5$, while the other boy has to travel distance $(100 - x)$ in time $t = (100 - x)/7$. Equating the times, $\dfrac{x}{5} = \dfrac{100 - x}{7}$

$\therefore \quad x = 41.7$ m

11. (a) : If θ is the phase difference between the current and the voltage,

$$\tan\theta = \frac{X_L}{R} = \frac{\omega L}{R} = \frac{2\pi\upsilon L}{R} = \frac{2(3.14)(50\text{ s}^{-1})(0.50\text{ H})}{100\,\Omega} = 1.57$$

$$\Rightarrow \theta = \tan^{-1}(1.57) = 57.5° \times \frac{\pi}{180}\text{ rad}$$

If Δt is the time lag between the current and voltage,

$$\frac{\theta}{\Delta t} = \frac{2\pi}{T} = \omega \;\Rightarrow\; \Delta t = \frac{\theta}{\omega} = \frac{\pi(57.5)}{180\times2\pi\times50}$$

$= 3.2 \times 10^{-3}$ s $= 3.2$ ms.

12. (d) : As, $3P \rightarrow Q + E_1$

$\Rightarrow \; E_1 = E_Q - 3E_P$

Also $2Q \rightarrow R + E_2$

$\Rightarrow \; E_2 = E_R - 2E_Q$

Now, $6P \rightarrow R + E_3$

$\Rightarrow \; E_R - 6E_P = E_3$

Now $2E_1 + E_2 = 2(E_Q - 3E_P) + (E_R - 2E_Q)$

$= E_3$

13. (b) : Here, $\upsilon = 400$ Hz, $v_s = 200$ m s^{-1}, $v = 300$ m s^{-1}

Before crossing the person

$$\upsilon_1 = \frac{v\times\upsilon}{v - v_s} = \frac{300\times400}{300-200} = 1200\text{ Hz}$$

After crossing the person,

$$\upsilon_2 = \frac{v\times\upsilon}{v + v_s} = \frac{300\times400}{300+200} = 240\text{ Hz}$$

Change in frequency $= \upsilon_1 - \upsilon_2 = 1200 - 240 = 960$ Hz

14. (c) : $v_e = \sqrt{2\,gR}$, $v_0 = \sqrt{gR}$

$$\therefore \quad \frac{\text{KE}_1}{\text{KE}_2} = \frac{\frac{1}{2}mv_e^2}{\frac{1}{2}mv_0^2} = \frac{v_e^2}{v_0^2} = 2$$

15. (a) **16. (b)**

17. (a) : Using Torricelli's theorem for the escape speed, we have for the volume flow

$$vA = \sqrt{2gh}\;A$$

$$= \sqrt{2(9.8\times10^3)(20\times10^3)}\times1$$

$= 19800$ mm^3 s^{-1} $= 19.8$ mL s^{-1}

18. (a) **19. (a)**

20. (c) : When the like poles are tied together, the net magnetic moment is $(m_1 + m_2)$ and the moment of inertia is $(I_1 + I_2)$.

$$\therefore \quad \text{The time period } T_1 = 2\pi\sqrt{\frac{I_1 + I_2}{(m_1 + m_2)B}}.$$

When the unlike poles are tied together, the net magnetic moment is $(m_1 - m_2)$, while the moment of inertia (being a scalar quantity) remains unchanged.

$$\therefore \quad \text{The time period } T_2 = 2\pi\sqrt{\frac{I_1 + I_2}{(m_1 - m_2)B}}.$$

Thus, $\dfrac{T_2^2}{T_1^2} = \dfrac{(m_1 + m_2)}{(m_1 - m_2)} \Rightarrow \dfrac{m_1}{m_2} = \dfrac{T_2^2 + T_1^2}{T_2^2 - T_1^2} = \dfrac{\upsilon_1^2 + \upsilon_2^2}{\upsilon_1^2 - \upsilon_2^2}.$

Given, $\upsilon_1 = 12$ per minute and $\upsilon_2 = 4$ per minute.

$$\therefore \quad \frac{m_1}{m_2} = \frac{12^2 + 4^2}{12^2 - 4^2} = \frac{144+16}{144-16} = \frac{160}{128} = \frac{5}{4}.$$

21. (b) : Amplitude of damped oscillation is

$A = A_0\, e^{-bt}$

As $A = A_0/2$, when $t = 1$ minute, so

$$\frac{A_0}{2} = A_0\, e^{-b \times 1} \quad \text{or} \quad e^b = 2$$

When $A = A_0/x$, $t = 3$ minute, then

$$\frac{A_0}{x} = A_0\, e^{-b \times 3} \quad \text{or} \quad x = e^{3b} = (e^b)^3 = 2^3$$

22. (a) : $\omega^2 = \omega_0^2 + 2\alpha\theta$,

$\omega_0 = 2\pi\upsilon = (2\pi \text{ rad})(30 \text{ s}^{-1}) = 60\,\pi \text{ rad s}^{-1}$ $(\because\ \omega = 0)$

$\therefore\ \ \theta = 326\pi$ rad.

$\alpha = -(60\pi)^2 / 652\pi$, or $\alpha = -17.3$ rad s^{-2}

$\tau = -0.015 \times 17.3$ m s^{-2} $= -0.26$ N m

23. (a) : Given, $L = 2$ H, $C = 32\ \mu\text{F} = 32 \times 10^{-6}$ F and $R = 10\ \Omega$.

If the resonant angular frequency of the circuit is ω_r then from the condition of resonance,

$$\Rightarrow \quad \omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(2\text{ H})(32 \times 10^{-6}\text{F})}} = 125 \text{ rad s}^{-1}.$$

The Q-factor of the circuit, $Q = \dfrac{\omega_r L}{R} = 25.$

24. (b) : Retardation $a = \dfrac{(u^2 - v^2)}{2x}$

$\therefore$ The force of resistance, $ma = \dfrac{m(u^2 - v^2)}{2x}$

25. (d) : $\lambda_p = \lambda_\alpha \Rightarrow \dfrac{h}{\sqrt{2m_p q_p V}} = \dfrac{h}{\sqrt{2m_\alpha q_\alpha V'}}$

or $\sqrt{2m_\alpha q_\alpha V'} = \sqrt{2m_p q_p V}$

Squaring both sides, we get

$$2m_\alpha q_\alpha V' = 2m_p q_p V;\ V' = \left(\frac{m_p}{m_\alpha}\right)\left(\frac{q_p}{q_\alpha}\right)V$$

As $\dfrac{m_p}{m_\alpha} = \dfrac{1}{4}$ and $\dfrac{q_p}{q_\alpha} = \dfrac{1}{2}$

$$\therefore\ V' = \left(\frac{1}{4}\right)\left(\frac{1}{2}\right)V = \frac{V}{8} \text{ volts}$$

26. (a) : First find the pressure at the top of the mercury pool. For a point below the surface of the mercury this may be regarded as a source of exerted pressure p_{ext}. Thus

$P_{\text{ext}} = \rho_{\text{water}} g h_{\text{water}} = 1.0 \times 9.8 \times 1.2 = 12$ kPa

The pressure P_{int} exerted by the mercury column itself is found in the same manner

$P_{\text{int}} = \rho_{\text{merc}} g h_{\text{merc}} = 13.6 \times 10 \times 9.8 \times 0.30$ m $= 40$ kPa

The total pressure at the bottom is thus 52 kPa.

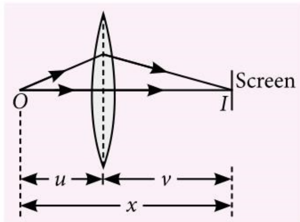
27. (d) : For open pipe, $\upsilon = p\dfrac{v}{2l}$

For closed pipe, $\upsilon' = (2p-1)\dfrac{v}{4l}$

$$\therefore \quad \frac{\upsilon}{\upsilon'} = \frac{2p}{2p-1}$$

28. (c) : Let the distance between the object O and its real image I be x, as shown in figure. Then,

$x = u + v$, ...(i)



where u and v are the numerical values of the distances of the object and the image from the convex lens.

For the convex lens, f and v will be positive, while u will be negative. From the lens formula,

$$\frac{1}{+v} - \frac{1}{-u} = \frac{1}{+f} \Rightarrow \frac{1}{u} = \frac{1}{f} - \frac{1}{v} = \frac{v-f}{fv} \Rightarrow u = \frac{fv}{v-f} \quad \text{...(ii)}$$

Substituting for u in equation (i),

$$x = \frac{vf}{v-f} + v = \frac{vf + v^2 - vf}{v-f} = \frac{v^2}{v-f}$$

$$\Rightarrow\ v^2 - vx + fx = 0 \quad \Rightarrow \quad v = \frac{x \pm \sqrt{x^2 - 4fx}}{2}$$

For real values of v,

$$x^2 - 4fx \ge 0 \quad \Rightarrow \quad x \ge 4f \quad \Rightarrow \quad f \le \frac{x}{4}.$$

Hence, for a fixed value of x (the distance between the object and the screen), the maximum value of the focal length of a convex lens that can form a real image at the screen is $x/4$. Since $x = 3$ m in this case,

$$f_{\max} = \frac{3}{4} = 0.75 \text{ m}.$$

29. (c)

30. (b) : Because there is no net torque on the system about the axis of rotation, the law of conservation of angular momentum tells us that angular momentum before = angular momentum after

$$I_0\omega_0 = I_f\omega_f$$

$$\frac{I_0}{I_f} = \frac{\omega_f}{\omega_0} = \frac{0.80}{0.25} = 3.2$$

31. (a) : Since the net angular dispersion is zero.

$\theta + \theta' = 0 \Rightarrow (\mu_v - \mu_r)A + (\mu'_v - \mu'_r)A' = 0$

$$\Rightarrow \omega(\mu_y - 1)A + \omega'(\mu'_y - 1)A' = 0 \Rightarrow \frac{A'}{A} = -\frac{\omega(\mu_y - 1)}{\omega'(\mu'_y - 1)}$$

Substituting the appropriate values,

$$\frac{A'}{A} = -\frac{0.03(1.517-1)}{0.05(1.621-1)} = -0.50. \qquad \text{...(i)}$$

The negative sign shows that the prisms are oppositely placed.

The net deviation of the yellow light produced by the given combination,

$D = \delta - \delta' = (\mu_y - 1)A - (\mu'_y - 1)A'$

$\Rightarrow\ 1° = (1.517 - 1)A' - (1.621 - 1)A'$

$1° = (0.517)A - (0.621)A' \qquad \text{...(ii)}$

From equations (i) and (ii),

$A = 4.8°$ and $A' = 2.4°$

32. (c) : Let the magnetic field at a distance r = 3 cm = 3×10^{-2} m from the axis be B. The area of the circular section of radius r is $A = \pi r^2$. The rms value of the conduction current, $I_{rms} = \frac{V_{rms}}{X_C} = V_{rms}\,\omega C$

$= 230 \times 300 \times 10^{-10} = 6.9 \times 10^{-6}$A

As the total conduction current is linked with the total area A of the circular plates, the rms value of the displacement current linked with area A'.

$$I'_d = \frac{A'}{A} I_{rms} = \frac{r^2}{R^2} I_{rms} = \frac{(3\text{ cm})^2}{(6\text{ cm})^2} \times (6.9 \times 10^{-6}\text{ A})$$

$= 1.7 \times 10^{-6}$ A

From the Ampere's circuital law,

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_d \Rightarrow B \times 2\pi r = \mu_0 I_d \Rightarrow B = \frac{\mu_0 I_d}{2\pi r}$$

$\therefore$ the amplitude of B,

$$B_0 = \sqrt{2}B = \frac{\sqrt{2}(4\pi \times 10^{-7}\text{ H m}^{-1})(1.7 \times 10^{-6}\text{ A})}{2\pi(3 \times 10^{-2}\text{ m})}$$

$= 7.6 \times 10^{-11}$T

33. (b) : Mass of the element of length dx at a distance x from the origin = $(A + Bx^2)dx$

$$\therefore\quad dF = \frac{Gm(A + Bx^2)dx}{x^2}$$

$$F = Gm\int_a^{a+L} \frac{(A + Bx^2)dx}{x^2} = Gm\int_a^{a+L}\left(\frac{A}{x^2} + B\right)dx$$

$$= Gm\left[A\left(\frac{1}{a} - \frac{1}{a+L}\right) + BL\right]$$

34. (a)

35. (b) : The diffraction pattern produced by a circular aperture consists of a central bright disc surrounded by alternate dark and bright rings that are concentric with the central disc. The angular radius of the central bright disc is given by

$$\sin\theta = 1.22\frac{\lambda}{a}.$$

Substituting λ = 550 nm = 550×10^{-9} m, and a = 10 cm

$$\sin\theta = \frac{(1.22)(550 \times 10^{-9}\text{ m})}{(10 \times 10^{-2}\text{ m})} = 0.67 \times 10^{-5}.$$

Radius of the bright disc,

$R = D\tan\theta \approx D\sin\theta \qquad (\because\ \theta$ is small)

where D = distance between the screen and the lens = 25 cm

$\therefore\quad R = (25\text{ cm})(0.67 \times 10^{-5}) = 1.67 \times 10^{-4}$ cm.

Diameter of the disc image = $2R = 2 \times (1.67 \times 10^{-4}$ cm)

$= 3.34 \times 10^{-4}$ cm

36. (b) : Efficiency, $\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$

Q_1 = (1 kcal)(4.184 kJ/kcal) = 4.184 kJ

$$\eta = \frac{Q_1 - Q_2}{4.184\text{ kJ}} = \frac{700\text{ K} - 450\text{ K}}{700\text{ K}}$$

Then $W = Q_1 - Q_2$ = 1.49 kJ

37. (a) : As $L = L_0(1 + \alpha\,\Delta T)$

$\therefore\quad \frac{\Delta L}{L_0} = \alpha\,\Delta T = (1.2 \times 10^{-5}\text{ °C}^{-1})(35\text{ °C}) = 4.2 \times 10^{-4}$

Then $F = YA\frac{\Delta L}{L_0} = (2 \times 10^{11}\text{ N m}^{-2})(45 \times 10^{-4}\text{ m}^2)$

$(4.2 \times 10^{-4}) \approx 380$ kN

38. (a) : The disintegration rate, $R = \left|\frac{dN}{dt}\right| = \lambda N$, where the decay constant, $\lambda = \frac{\ln 2}{T_{1/2}}$

The half-life, $T_{1/2}$ = 28 years = $28 \times 3.156 \times 10^7$ s

$= 8.83 \times 10^8$ s

The mass of the given sample, M = 15 mg = 15×10^{-3} g

The molar mass, M_m = 90 g mol^{-1}

The number of moles, $\frac{M}{M_m} = \frac{N}{N_A}$

$$\Rightarrow\quad N = \frac{M}{M_m}N_A = \frac{(15 \times 10^{-3}\text{ g})}{(90\text{ g mol}^{-1})} \times (6.022 \times 10^{23}\text{ mol}^{-1})$$

$= 1 \times 10^{20} = 10^{20}$.

$$\therefore\quad R = \lambda N = \frac{\ln 2}{T_{1/2}}N = \frac{0.693}{8.83 \times 10^8\text{ s}} \times 10^{20} = 7.84 \times 10^{10}\ \text{s}^{-1}$$

$$= 7.84 \times 10^{10}\text{ Bq} = \frac{7.84 \times 10^{10}}{3.7 \times 10^{10}}\text{ Ci} = 2.12\text{ Ci}$$

39. (c) : $E = \frac{1}{4\pi\varepsilon_0} \cdot \left[\frac{5\times10^{-9}}{(1\times10^{-2})^2} - \frac{5\times10^{-9}}{(2\times10^{-2})^2} + \frac{5\times10^{-9}}{(4\times10^{-2})^2} - \frac{(5\times10^{-9})}{(8\times10^{-2})^2} + ... \right]$

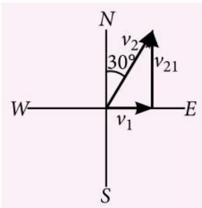
$$\Rightarrow \quad E = \frac{9\times10^9 \times 5\times10^{-9}}{10^{-4}} \left[1 - \frac{1}{(2)^2} + \frac{1}{(4)^2} - \frac{1}{(8)^2} + ... \right]$$

$$\Rightarrow \quad E = 45 \times 10^4 . \left[1 + \frac{1}{(4)^2} + \frac{1}{(16)^2} + ... \right] - 45 \times 10^4 \left[\frac{1}{(2)^2} + \frac{1}{(8)^2} + \frac{1}{(32)^2} + ... \right]$$

$$\Rightarrow \quad E = 45 \times 10^4 \left[\frac{1}{1 - \frac{1}{16}} \right] - \frac{45\times10^4}{(2)^2} \left[1 + \frac{1}{4^2} + \frac{1}{(16)^2} + ... \right]$$

$E = 48 \times 10^4 - 12 \times 10^4 = 36 \times 10^4$ N C^{-1}

40. (d) : v_1 = velocity of first ship relative to the earth ; v_2 = velocity of second ship relative to the earth. Let v_{21} = relative velocity of second ship with respect to first ship. Then $v_2 = v_{21} + v_1$, where v_{21} is due north.



Thus, $v_2 \sin 30° = v_1 = 10$ km h$^{-1} \Rightarrow v_2 = 20$ km h^{-1}.

41. (d) : Since the total number of transitions is

$$\frac{n(n-1)}{2} = 6 \Rightarrow n = 4$$

Hence, the highest excitation state is $n = 4$.

The energy required to excite the atom from $n = 1$ to $n = 4$ is

$$\Delta E = E_4 - E_1 = -\frac{13.6}{4^2}\,\text{eV} - \left(-\frac{13.6}{1^2}\,\text{eV} \right)$$

$$= 13.6\left(1 - \frac{1}{16} \right)\text{eV} = 12.75\text{ eV}$$

Thus, the energy of the incident photons,

$$h\upsilon = 12.75\text{ eV} \Rightarrow \frac{hc}{\lambda} = 12.75\text{ eV}$$

$$\Rightarrow \quad \lambda = \frac{hc}{12.75\text{ eV}} = \frac{12420\text{ eV Å}}{12.75\text{ eV}} = 975\text{ Å}$$

42. (c) : Let Q' be the heat per gram of coal. Then

$(5\text{ g})Q' = mc\,\Delta t = (1000\text{ g})(1.00\text{ cal g}^{-1}\,°\text{C}^{-1})(37\,°\text{C})$

$Q = 7400$ cal g^{-1}

43. (a) : $I = ne\,A\,v_d$ or $v_d = \frac{I}{n\,A\,e} = \frac{q/t}{n\,A\,e}$

Number of free electrons per unit length of conductor

$N = nA \times 1$

$\therefore$ Momentum of all the free electrons is

$$p = N\,mv_d = nA \times m \times \frac{q/t}{n\,A\,e} = \frac{q/t}{(e/m)} = \frac{q}{t\,s}$$

44. (b) : $v_0 = 20$ m s^{-1} and $\theta_0 = 40°$, we get

$v_{0x} = v_0 \cos\theta_0 = (20\text{ m s}^{-1})\cos 40° = 15.3$ m s^{-1}

$v_{0y} = v_0 \sin\theta_0 = (20\text{ m s}^{-1}) \sin 40° = 12.8$ m s^{-1}

As, $x = v_{0x}t$

8 m = (15.3 m s^{-1})t, or, $t = 0.52$ s.

Required height of the wall is given by, $y = v_{0y}t - \frac{1}{2}gt^2$,

$h = (12.8\text{ m s}^{-1})\,(0.52\text{ s}) - (4.9\text{ m s}^{-2})(0.52\text{ s})^2 = 5.33$ m.

45. (c) : The capacitances of the two layers are given by

$$C_1 = \frac{2\varepsilon_0\,A}{d}\,;\; C_2 = \frac{6\varepsilon_0\,A}{2d}$$

As q is same on each condenser, therefore,

$$V_1 = \frac{q}{C_1} \text{ and } V_2 = \frac{q}{C_2}$$

$$\therefore \quad \frac{V_1}{V_2} = \frac{C_2}{C_1} = \frac{6\varepsilon_0\,A}{2d} \times \frac{d}{2\varepsilon_0\,A} = \frac{3}{2}$$

◈◈

PHYSICS MUSING

SOLUTION SET-55

1. **(c) :** Let v_A and v_B be velocities of shells A and B respectively. Since, no external force acting. Hence, momentum is conserved.

$$\therefore \quad mv_A = 2mv_B \text{ or } \frac{v_A}{v_B} = \frac{2}{1}$$

Also $\dfrac{K_A}{K_B} = \dfrac{\frac{1}{2}mv_A^2}{\frac{1}{2}2mv_B^2} = 2$

$\dfrac{K_A}{K_B} = 2$ (where K_A and K_B are kinetic energies of A and B respectively) ...(i)

From conservation of mechanical energy,

$U_i + K_i = U_f + K_f$

$$\text{or} \quad \frac{-kQ^2}{10R} + 0 = \frac{-kQ^2}{2R} + K_A + K_B$$

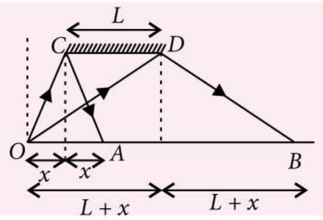
$$\therefore \quad K_A + K_B = \frac{-kQ^2}{10R} + \frac{kQ^2}{2R} = \frac{kQ^2}{2R}\left(1 - \frac{1}{5}\right)$$

$$\therefore \quad K_A + \frac{K_A}{2} = \frac{kQ^2}{2R}\left(\frac{4}{5}\right) \quad \text{(using (i)}$$

$$\Rightarrow \quad \frac{3}{2}K_A = \frac{2}{5}\frac{kQ^2}{R} \Rightarrow K_A = \frac{4}{15}\frac{kQ^2}{R}$$

$$\text{or} \quad \frac{1}{2}mv_A^2 = \frac{4}{15}\frac{kQ^2}{R} \quad \therefore \quad v_A = \sqrt{\frac{8}{15m}\frac{kQ^2}{R}}$$

2. **(b) :**



Length of light spot $= AB = OB - OA$
$= 2(L + x) - 2x = 2L =$ constant.

Hence the rate of change of length of light is zero.

3. **(a) :** Let v_{IM} and v_{OM} be the relative velocities of image and object w.r.t. mirror respectively.

Therefore, $v_{IM} = -v_{OM}$ (normal to plane mirror)

$\Rightarrow \quad v_I - v_M = -(v_O - v_M)$, where v_M is the velocity of mirror w.r.t. ground.

$\Rightarrow \quad v_I - v\sin\theta = -(0 - v\sin\theta) \quad \Rightarrow \quad v_I = 2v\sin\theta$

4. **(d) :** At equilibrium, pressure and temperature are same.

$\therefore \quad P_1 = P_2$ and $T_1 = T_2$

Also, let cross-sectional area of tube be A and radius of ring be r.

$$\therefore \quad \frac{V_1}{n_1} = \frac{V_2}{n_2}$$

$$\Rightarrow \quad \frac{2\pi - \alpha}{n_1} = \frac{\alpha}{n_2}$$

$(\because\ V_1 = (2\pi - \alpha)\,rA$ and $V_2 = \alpha\, rA$

$$\Rightarrow \quad M_1(2\pi - \alpha) = M_2\alpha \quad \left[\because\ n_1 = \frac{m}{M_1} \text{ and } n_2 = \frac{m}{M_2}\right]$$

$$\text{or} \quad \alpha = \frac{2\pi M_1}{M_1 + M_2} = \frac{16\pi}{15}$$

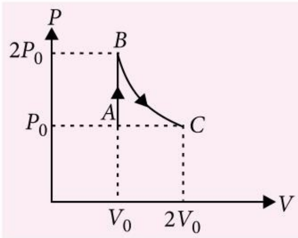
5. **(c) :** In process AB,

$Q_{AB} = \Delta U_{AB} + W_{AB}$

As $W_{AB} = 0$ and

$$\Delta U_{AB} = \frac{f}{2}nR\Delta T = \frac{f}{2}(\Delta PV)$$

$$\Delta U_{AB} = \frac{5}{2}(\Delta PV)$$



$Q_{AB} = 2.5P_0V_0$

In process BC,

$Q_{BC} = \Delta U_{BC} + W_{BC}$

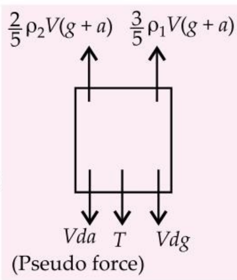
$Q_{BC} = 0 + 2P_0V_0 \ln 2$

$= 1.4P_0V_0$

Total heat given to gas is

$Q_{\text{net}} = Q_{AB} + Q_{BC} = 3.9P_0V_0$

6. **(b) :** We analysed this problem from the reference frame of elevator. Total buoyant force on the block,



$$F_B = \left(\frac{2}{5}V\rho_2 + \frac{3}{5}V\rho_1\right)(g + a)$$

For equilibrium,

$F_B = T + Vd(g + a)$

or $\quad T = F_B - Vd(g + a)$

$$= (g + a)V\left[\frac{2}{5}\rho_2 + \frac{3}{5}\rho_1 - d\right]$$

$$T = \left(10 + \frac{10}{2}\right)\times 10^{-3}\left[\frac{2}{5}\times 1500 + \frac{3}{5}\times 1000 - 800\right]$$

$= 6$ N

Contd. on Page No. 81

Exam on 20th May

JEE ADVANCED

PRACTICE PAPER 2018

PAPER - I

Section 1 (Maximum Marks : 28)

- *This section contains SEVEN questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four options is(are) correct.*
- *For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

  Full Marks : +4 *If only the bubble(s) corresponding to all the correct option(s) is(are) darkened.*

  Partial Marks : +1 *For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*

  Zero Marks : 0 *If none of the bubbles is darkened.*

  Negative Marks : –2 *In all other cases.*
- *For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (a) and (d) will get +2 marks; and darkening (a) and (b) will get –2 marks, as a wrong option is also darkened.*

1. A light bulb filament is constructed from 2 cm of tungsten wire of diameter 50 μm and is enclosed in an evacuated glass bulb. What temperature does the filament reach when it is operated at a power of 1 W? (Assume the emissivity of the tungsten surface to be 0.4.)

(a) 1.94×10^3 K (b) 2.94×10^3 K
(c) 3.88×10^3 K (d) 5.94×10^3 K

2. The electric potential at a perpendicular distance r from a long charged straight wire of cross-sectional radius a is given by $V(r) = -K \ln \frac{r}{a}$, where K is a constant.

Now a second identical wire, carrying charge per unit length $-q$, is placed parallel to the first at a distance d from it. Both the wires have equal and opposite charges. V is the potential difference between the wires. Which of following expressions is/are correct?

(a) $|q| = 2\pi K\varepsilon_0$ (b) $|q| = 4\pi K\varepsilon_0$
(c) $V = 2K \ln \frac{d-a}{a}$ (d) $V = 4K \ln \frac{d-a}{a}$

3. A gun of mass M whose barrel makes an angle α with the horizontal fires a shell of mass m. The gun is mounted on a frictionless track, so that recoil takes place with no resistive forces. The velocity of the shell relative to the barrel is v. The absolute velocity of the shell makes an angle β with the horizontal. Which of the following options is/are correct?

(a) The recoil velocity of the gun is $\frac{mv\cos\alpha}{m+M}$

(b) The recoil velocity of the gun is $\frac{mv\sin\alpha}{m+M}$

(c) $\tan\beta = \left(1+\frac{m}{M}\right)\tan\alpha$

(d) $\tan\beta = \tan\alpha$

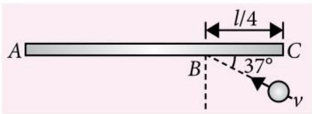
4. A circular parallel-plate capacitor of radius a and plate separation d is connected in series with a resistor R and a switch, initially open, to a constant voltage source V_0. The switch is closed at time $t = 0$. Assuming that the charging time of the capacitor, $\tau = CR$, C is the capacitance, j_d and B are the displacement current density and the magnetic flux density as a function of time t and r. (r is the radius of amperean loop between the capacitor plates). Then,

(a) $j_d = \frac{V_0}{\pi a^2 R}(e^{-t/\tau})$ (b) $j_d = \frac{V_0}{2\pi a^2 R}(e^{-2t/\tau})$

(c) $B = \frac{\mu_0 r V_0}{4\pi a^2 R}(e^{-2t/\tau})$ (d) $B = \frac{\mu_0 r V_0}{2\pi a^2 R}(e^{-t/\tau})$

5. A rod AC of length l and mass m is kept on a horizontal smooth plane. It is free to rotate and move. A particle of same mass m moving on the plane with velocity v strikes the rod at point B

making angle 37° with the rod as shown in figure. The collision is elastic. ($\sin 37° = 3/5$.)



After collision,

(a) the angular velocity of the rod will be $62v/55l$
(b) the centre of the rod will travel a distance $\pi l/3$ in the time in which it makes half rotation
(c) impulse of the impact force is $24mv/55$
(d) the angular velocity of the rod will be $72v/55l$

6. A sphere of uniform density ρ has a spherical cavity within it whose centre is at a distance a from the centre of the sphere. The gravitational field within the cavity is

(a) uniform (b) non-uniform
(c) $\frac{4}{3}\pi G\rho a$ (d) $\frac{2}{3}\pi G\rho a$

7. Four rods P, Q, R and S of the same length and material but of different radii r, $r\sqrt{2}$, $r\sqrt{3}$ and $2r$, respectively, are held between two rigid walls. The temperature of all rods is increased through the same range. If the rods do not bend, then

(a) the stress in the rods P, Q, R and S are in the ratio 1 : 2 : 3 : 4
(b) the forces on them exerted by the wall are in the ratio 1 : 2 : 3 : 4
(c) the energy stored in the rods due to elasticity are in the ratio 1 : 2 : 3 : 4
(d) the strains produced in the rods are in the ratio 1 : 2 : 3 : 4

Section 2 (Maximum Marks : 15)

- *This section contains FIVE questions.*
- *The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 to 9, both inclusive.*
- *For each question, darken the bubble corresponding to the correct integer in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

Full Marks : +3 *If only the bubble corresponding to the correct answer is darkened.*
Zero Marks : 0 *In all other cases.*

8. A thin wire of length $l = 1$ m is shaped into a semicircle with diameter. The force per unit length at the mid-point of the diameter when it carries a current $I = 8$ A is 1.03×10^{-x} N. Find x. (Take $\pi = 3.14$)

9. A sphere of mass M and radius r as slips on a rough horizontal plane. At some instant it has translational velocity v_0 and rotational velocity about the centre $\frac{v_0}{2r}$. The translational velocity after the sphere starts pure rolling is $\frac{nv_0}{7}$. Find n.

10. A source emitting sound of frequency 180 Hz is placed in front of a wall at a distance of 2 m from it. A detector is also placed in front of the wall at the same distance from it. Find the minimum distance (in m) between the source and the detector for which the detector detects a maximum of sound. Speed of sound in air = 360 m s^{-1}.

11. A proton of mass $m = 1.67 \times 10^{-27}$ kg moves uniformly in a space where there are uniform, mutually perpendicular electric and magnetic fields with $E_z = 4.5 \times 10^4$ V m^{-1} and $B_x = 40$ mT at an angle $\phi = 60°$ with the x-axis in the xy-plane. Find the pitch of the trajectory after the electric field is switched off.

12. A count rate meter is used to measure the activity of a given sample. At one instant, the meter shows 4750 counts per minute. Five minutes later, it shows 2700 counts per minute. Find the half-life (in min) of the sample. ($\log_{10} 1.760 = 0.2455$)

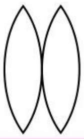
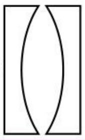
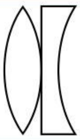
Section 3 (Maximum Marks : 18)

- *This section contains SIX questions of matching type.*
- *This section contains TWO tables (each having 3 columns and 4 rows).*
- *Based on each table, there are THREE questions.*
- *Each question has FOUR options (a), (b), (c), and (d). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

Full Marks : +3 *If only the bubble corresponding to the correct option is darkened.*
Zero Marks : 0 *If none of the bubbles is darkened*
Negative Marks : –1 *In all other cases*

Answer Q.13, Q.14 and Q.15 by appropriately matching the information given in the three columns of the following table.

An object is placed at different positions (u) in front of different lens combinations. The radius of curvature of curved surface is r and the refractive index of each lens is 1.5. The object positions u, lens combinations and nature of image formed by the combined lens are given in column 1, 2 and 3 respectively.

Column 1	Column 2	Column 3
(I) $u = 2r$	(i) 	(P) Smaller and real
(II) $u = r$	(ii) 	(Q) Smaller and virtual
(III) $u = r/2$	(iii) 	(R) Larger and real
(IV) $u = \infty$	(iv) 	(S) Larger and virtual

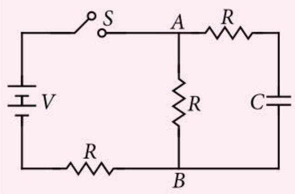
13. Which of the following combinations may be used to correct myopic eye?
(a) (III) (iv) (Q) (b) (IV) (iii) (Q)
(c) (IV) (i) (P) (d) (II) (iii) (R)

14. Which of the following combinations is correct if the image of an object formed at infinity?
(a) (III) (iii) (P) (b) (I) (ii) (P)
(c) (II) (iv) (Q) (d) (III) (i) (R)

15. Which of following combinations has magnification greater than 1?
(a) (III) (iv) (S) (b) (II) (ii) (S)
(c) (III) (ii) (R) (d) (I) (iii) (R)

Answer Q. 16, Q.17 and Q. 18 by appropriately matching the information given in the three columns of the following table.

In the given circuit diagram, the battery is ideal one with emf V. The capacitor is initially uncharged. The switch S is closed at $t = 0$. At any time t, charge on capacitor is Q and current in branch AB is I. The time t, for which switch is closed, current I and charge Q are given in columns 1, 2 and 3 respectively.



Column 1	Column 2	Column 3
(I) $3RC/2$	(i) 0	(P) $\frac{CV}{2}$
(II) ∞	(ii) $\frac{V}{R}\left(\frac{1}{2}-\frac{1}{6e}\right)$	(Q) 0
(III) $3RC$	(iii) $\frac{V}{3R}$	(R) $\frac{CV}{2}\left(1-\frac{1}{e}\right)$
(IV) 0	(iv) $\frac{V}{2R}$	(S) ∞

16. Which of the following combinations is correct regarding minimum charge on the capacitor?
(a) (II) (iv) (P)
(b) (IV) (i) (Q)
(c) (IV) (iii) (Q)
(d) (III) (ii) (R)

17. Which of the following combinations is equivalent to charged stored in the capacitor at time which is five times of time constant of given circuit?
(a) (III) (iii) (S)
(b) (II) (iv) (P)
(c) (III) (iv) (P)
(d) (II) (ii) (S)

18. Which of the following combinations is possible?
(a) (II) (iii) (P)
(b) (II) (iv) (S)
(c) (III) (ii) (R)
(d) (I) (ii) (R)

Paper - II

Section 1 (Maximum Marks : 21)

- *This section contains SEVEN questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

Full Marks : +3 *If only the bubble corresponding to the correct option is darkened.*
Zero Marks : 0 *If none of the bubbles is darkened.*
Negative Marks : –1 *In all other cases.*

1. Two moles of a certain ideal gas at a temperature 300 K were cooled isochorically so that the gas pressure reduced 2.0 times. Then, as a result of the isobaric process, the gas expanded till its temperature got back to the initial value. Find the total amount of heat absorbed by the gas in both processes. (γ is adiabatic exponent of gas.)

(a) $\frac{300R}{\gamma-1}$ (b) $\frac{150R}{\gamma-1}$ (c) $150\,R$ (d) $300\,R$

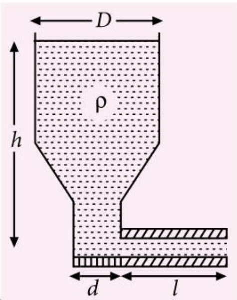
2. Two spherical planets P and Q have the same uniform density ρ, masses M_P and M_Q, and surface areas A and $4A$, respectively. A spherical planet W also has uniform density ρ and its mass is $(M_P + M_Q)$. The escape velocities from the planets P, Q and W are v_P, v_Q and v_W, respectively. Then

(a) $v_Q > v_W > v_P$ (b) $v_W > v_Q > v_P$
(c) $v_W > v_Q = v_P$ (d) $v_W < v_Q = v_P$

3. When an uncharged conducting ball of radius R is placed in an external uniform electric field, a surface charge density $\sigma = \sigma_0 \cos\theta$ is induced on the ball's surface where σ_0 is a constant and θ is a polar angle. Find the resultant electric force acting on an induced charge of the same sign.

(a) $\dfrac{\pi\sigma_0^2 R^2}{4\varepsilon_0}$ (b) $\dfrac{\pi\sigma_0^2 R^2}{2\varepsilon_0}$
(c) $\dfrac{\pi\sigma_0^2 R^2}{3\varepsilon_0}$ (d) $\dfrac{\pi\sigma_0^2 R^2}{5\varepsilon_0}$

4. Shown in the figure is a container whose top and bottom diameters are D and d respectively. At the bottom of the container, there is a capillary tube of outer radius b and inner radius a. The volume flow rate in the capillary is Q.

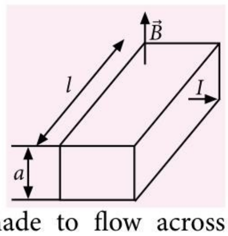


If the capillary is removed the liquid comes out with a velocity of v_0. The density of the liquid is given as ρ. Calculate the coefficient of viscosity η.

(a) $\dfrac{\pi\rho v_0^2}{4Ql}\left(1-\dfrac{d^4}{D^4}\right)a^4$ (b) $\dfrac{\pi\rho v_0^2}{16Ql}\left(1-\dfrac{d^4}{D^4}\right)a^4$

(c) $\dfrac{\pi\rho v_0^2}{8Ql}\left(1-\dfrac{d^4}{D^4}\right)a^4$ (d) $\dfrac{\pi\rho v_0^2}{12Ql}\left(1-\dfrac{d^4}{D^4}\right)a^4$

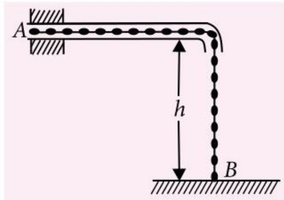
5. An electromagnetic pump designed for transferring molten metals. A pipe section with metal is located in a uniform magnetic field of induction $\vec{B}$ as shown in the figure.



A current I is made to flow across this pipe section in the direction perpendicular both to the vector $\vec{B}$ and to the axis of the pipe. Find the gauge pressure produced by the pump if $B = 0.10$ T, $I = 100$ A, $l = 1$ m and $a = 2.0$ cm.

(a) 500 N (b) 1000 N
(c) 1500 N (d) 2000 N

6. A chain AB of length l is located in a smooth horizontal tube so that its fraction of length h hangs freely and touches the surface of the table with its end B as shown in the figure.

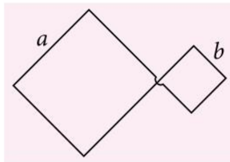


At a certain moment the end A of the chain is set free. With what velocity will this end of the chain slip out of the tube?

(a) $\sqrt{gh\ln\left(\dfrac{l}{h}\right)}$ (b) $2\sqrt{gh\ln\left(\dfrac{l}{h}\right)}$

(c) $\sqrt{2gh\ln\left(\dfrac{l}{h}\right)}$ (d) $2g\sqrt{h\ln\left(\dfrac{l}{h}\right)}$

7. A plane loop shown in figure is shaped as two squares with sides a = 20 cm and b = 10 cm and is introduced into a uniform magnetic field at right angles to the loop's plane.



The magnetic induction varies with time as $B = B_0 \sin\omega t$, where $B_0 = 10$ mT and $\omega = 100$ rad s^{-1}. Find the amplitude of the current induced in the loop if its resistance per unit length is equal to $\rho = 50$ mΩ m^{-1}. The inductance of the loop is to be neglected.

(a) 5 A (b) 0.5 A (c) 0.2 A (d) 2 A

Section 2 (Maximum Marks : 28)

- *This section contains SEVEN questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four options is(are) correct.*
- *For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

Full Marks : +4 *If only the bubble(s) corresponding to all the correct option(s) is(are) darkened.*

Partial Marks: +1 *For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*

Zero Marks : 0 *If none of the bubbles is darkened.*

Negative Marks : –2 *In all other cases.*

- *For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks; and darkening (a) and (b) will result in –2 marks, as a wrong option is also darkened.*

8. A solid body rotates with a constant angular velocity 0.50 rad s^{-1} about a horizontal axis AB. At time $t = 0$ the axis AB starts turning about the vertical with a constant angular acceleration 0.10 rad s^{-2}. If

the angular velocity and angular acceleration of the body after time $t = 3.5$ s are ω and α respectively, then

(a) $\omega = 0.6$ rad s^{-1} (b) $\omega = 0.15$ rad s^{-1}
(c) $\alpha = 0.2$ rad s^{-2} (d) $\alpha = 0.1$ rad s^{-2}

9. Light from a discharge tube containing hydrogen atoms falls on the surface of a piece of sodium. The kinetic energy of the fastest photoelectrons emitted from sodium is 0.73 eV. The work function for sodium is 1.82 eV. Then choose the correct option(s).
(Ionization potential of hydrogen is 13.6 eV; mass of hydrogen atom = 1.6×10^{-27} kg)
(a) The energy of the photons causing the photoelectric emission is 2.55 eV.
(b) The quantum numbers (n) of the two levels involved in the emission of these photons are 2 and 4.
(c) The change in the angular momentum of the electron in the hydrogen atom in the transition is $3h/\pi$.
(d) The recoil speed of the emitting atom assuming it to be at rest before the transition is 0.814 m s^{-1}.

10. A particle executes simple harmonic motion in a straight line such that in two of its positions the velocities are u and v and the corresponding accelerations are α and β ($0 < \alpha < \beta$). The distance between the positions is x and the period of motion is T. Then,

(a) $T = 2\pi\sqrt{\dfrac{u^2+v^2}{\beta^2+\alpha^2}}$ (b) $T = 2\pi\sqrt{\dfrac{u^2-v^2}{\beta^2-\alpha^2}}$

(c) $x = \dfrac{u^2-v^2}{\alpha+\beta}$ (d) $x = \dfrac{u^2+v^2}{\alpha-\beta}$

11. A body of mass m is hauled from the Earth's surface by applying a force $\vec{F}$ varying with the height of ascent y as $\vec{F} = 2(ay - 1)m\vec{g}$ where a is a positive constant and $\vec{g}$ is the acceleration due to gravity. When body rises first half of ascent then
(a) work done by force F is $3mg/4a$.
(b) work done by force F is $3mg/a$.
(c) change in gravitational potential energy is $mg/2a$.
(d) change in gravitational potential energy is mg/a.

12. An observer A is moving directly towards a stationary sound source while another observer B is moving away from the source with the same velocity. Which of the following statements is/are correct?
(a) Average of frequencies recorded by A and B is equal to natural frequency of the source.
(b) Wavelength of wave received by A is less than that of waves received by B.
(c) Wavelength of waves received by two observers will be same.
(d) Both the observers will observe the wave travelling with same speed.

13. A superconducting round ring of radius a and inductance L was located in a uniform magnetic field of induction $\vec{B}$. The plane of ring was parallel to the vector $\vec{B}$, and the current in the ring was equal to zero. Then the ring was turned through 90° so that its plane became perpendicular to the field. Choose the correct statement(s).
(a) The current induced in the ring after the turn is $\dfrac{\pi a^2 B}{2L}$.
(b) The work performed during the turn is $\dfrac{\pi^2 a^4 B^2}{2L}$.
(c) No current is induced in the ring.
(d) The work performed during the turn is $\dfrac{\pi}{4}\dfrac{a^4 B^2}{L}$.

14. For a certain metal, the K absorption edge is at 0.172 Å. The wavelength of K_α, K_β, and K_γ lines of K series are 0.210 Å, 0.192 Å and 0.180 Å respectively. The energies of K, L and M orbits are E_K, E_L and E_M, respectively. Then
(a) $E_K = -13.92$ keV (b) $E_L = -8.37$ keV
(c) $E_M = -4.06$ keV (d) $E_K = -13.04$ keV

Section 3 (Maximum Marks : 12)

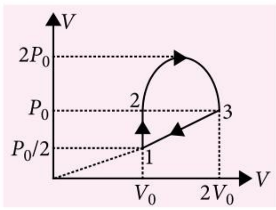
- *This section contains TWO paragraphs.*
- *Based on each paragraph, there are TWO questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

Full Marks : +3 *If only the bubble corresponding to the correct option is darkened.*

Zero Marks : 0 *In all other cases.*

PARAGRAPH 1

2 mole of monatomic ideal gas undergoes the shown cyclic process in which path of the process 2 → 3 is a semicircle.



15. Heat given to the system in semicircular process is

(a) $\frac{P_0V_0}{2}\left(7-\frac{\pi}{4}\right)$ (b) $\frac{P_0V_0}{3}\left(7+\frac{\pi}{4}\right)$

(c) $\frac{P_0V_0}{2}\left(7+\frac{\pi}{4}\right)$ (d) $\frac{P_0V_0}{3}\left(7-\frac{\pi}{4}\right)$

16. Total heat rejected in one cycle is

(a) $\frac{P_0V_0(32-\pi)}{4}$ (b) $\frac{P_0V_0(32+\pi)}{4}$

(c) $\frac{P_0V_0(32+\pi)}{8}$ (d) $\frac{P_0V_0(32-\pi)}{8}$

PARAGRAPH 2

In a photoelectric setup, a point source of light of power 3.2×10^{-3} W emits monoenergetic photons of energy 5.0 eV. The source is located at a distance of 0.8 m from the center of a stationary metallic sphere of work function 3.0 eV and of radius 8.0×10^{-3} m. The efficiency of photoelectron emission is 1 for every 10^6 incident photons. Assume that the sphere is isolated and initially neutral and that photoelectrons are instantaneously swept away after emission.

17. Calculate the number of photoelectrons emitted per second.

(a) 10^3 (b) 10^4 (c) 5×10^4 (d) 10^5

18. It is observed that photoelectron emission stops at a certain time t after the light source is switched on. It is due to the retarding potential developed in the metallic sphere due to left over positive charges. The stopping potential (V) can be represented as (e = charge on electron)

(a) $2(KE_{max}/e)$ (b) (KE_{max}/e)

(c) $(KE_{max}/3e)$ (d) $(KE_{max}/2e)$

SOLUTIONS

PAPER - 1

1. (a) : The power radiated by area A of a black body at temperature T is given by Stefan's law

$$\frac{P}{A} = \sigma T^4$$

where σ is the Stefan-Boltzmann constant. Thus the power per unit area radiated by a body of emissivity ε is $\varepsilon\sigma T^4$.

If the body's surroundings are at a temperature T_0, it will absorb power per unit area of $\varepsilon\sigma T_0^4$ from them, so the net power emitted is

$$P = \varepsilon\sigma(T^4 - T_0^4)A$$

Here, $\varepsilon = 0.4$, $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}, $P = 1$ W

$A = \pi \times 0.02 \times 50 \times 10^{-6}$ m^2 $= 3.14 \times 10^{-6}$ m^2

$$T^4 - T_0^4 = \frac{\rho}{\varepsilon A\sigma} = \frac{1}{0.4\times 3.14\times 10^{-6}\times 5.67\times 10^{-8}}$$
$$= 1.404 \times 10^{13}\ \mathrm{K}^4.$$

It is clear that the temperature T_0 of the surroundings can be ignored, so we obtain $T = 1.94 \times 10^3$ K.

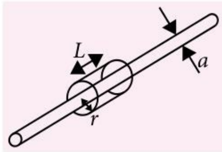
2. (a, c) : Given $V(r) = -K\ln\left(\frac{r}{a}\right)$

$$E = -\frac{dV}{dr} = K/r.$$

Gauss's theorem states that, for a closed region of space,

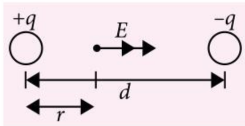
$$\int \vec{E}\cdot d\vec{S} = \frac{1}{\varepsilon_0}\sum Q,$$

where $\vec{E}$ is the electric field vector on the surface of the region, $d\vec{S}$ is an element of the vector area of the surface (pointing outwards), and ΣQ is the total charge contained within the region of space.



$\therefore\ Q = 2\pi rLE\varepsilon_0 = 2\pi KL\varepsilon_0$

So the charge per unit length of the wire is $q = 2\pi K\varepsilon_0$.



The field at r due to the wire carrying charge per unit length $+q$ is K/r, and the field due to the wire carrying charge per unit length $-q = K/(d-r)$.

$$E = K\left(\frac{1}{r}+\frac{1}{d-r}\right)$$

The potential difference between the wires is found by integrating the field with respect to r, from $r = a$ to $r = d - a$:

$$V = K\int_a^{d-a}\left(\frac{1}{r}+\frac{1}{d-r}\right)dr = K[\ln r - \ln(d-r)]_a^{d-a}$$
$$= 2K\ln\frac{d-a}{a}$$

3. (a, c) : Since there is no horizontal force on the system (gun + shell + explosives) the horizontal momentum is conserved.

Horizontal relative velocity of the shell = $v\cos\alpha$.

If v_{abs} be the absolute horizontal velocity of the shell, then $v_{abs} = v\cos\alpha - V$

Here, V is the recoil speed of the gun.

By conservation of linear momentum

$$m(v\cos\alpha - V) - MV = 0 \text{ or } V = \frac{mv\cos\alpha}{m+M}$$

The components of the absolute velocity of the shell are $(v\cos\alpha - V)$ and $v\sin\alpha$.

Thus, absolute velocity of the shell

$$= \sqrt{(v\cos\alpha - V)^2 + (v\sin\alpha)^2}$$

$$= v\sqrt{1 - \frac{m(m+2M)}{(m+M)^2}\cos^2\alpha}$$

$$\tan\beta = \frac{v\sin\alpha}{v\cos\alpha - V} = \left(1 + \frac{m}{M}\right)\tan\alpha$$

4. (a, d) : The charge on the capacitor plates at time t is given by $Q = CV_0(1 - e^{-t/\tau})$,

$\therefore$ The charge density on the plates, $\rho = \frac{CV_0}{A}(1 - e^{-t/\tau})$,

where $A = \pi a^2$ is the area of the plates. Since the displacement current density j_d is equal to the rate of change of charge density we must have

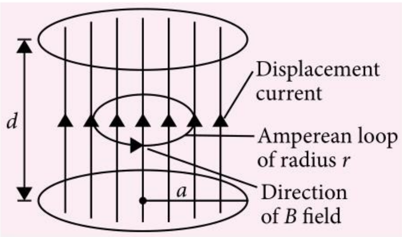
$$j_d = \frac{CV_0}{A\tau}(e^{-t/\tau})$$

Since $\tau = CR$ and $A = \pi a^2$, we may write this as

$$\therefore\ j_d = \frac{V_0}{\pi a^2 R}e^{-t/\tau}$$

If we consider a circular loop of radius r concentric with the capacitor, as shown in figure, it links a total displacement current,

$$I_d = \pi r^2 j_d = \frac{r^2 V_0}{a^2 R}e^{-t/\tau}$$



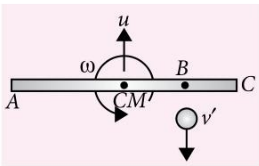
Using Ampere's law,

$$\int \vec{B}\cdot d\vec{l} = \mu_0 I_d$$

$$2\pi r B = \mu_0 I_d$$

$$B = \frac{\mu_0 r V_0}{2\pi a^2 R}e^{-t/\tau}$$

5. (b, c, d) : The ball has v' component of its velocity perpendicular to the length of the rod immediately after the collision. u is the velocity of CM of the rod and ω is angular velocity of the rod just after collision. The ball strikes the rod with a speed of v sin 37° in the perpendicular direction and its component along the length of the rod (*i.e.*, v cos 37°) after the collision is unchanged.



$\therefore$ Velocity of separation = Velocity of approach

$$\frac{3v}{5} = \left(\frac{\omega l}{4} + u\right) + v'$$

Conserving linear momentum (of rod + particle) in the direction perpendicular to the rod,

$$mv\frac{3}{5} = mu - mv'$$

Conserving angular momentum about point CM as shown in the figure.

$$\left(\frac{3}{5}mv\right)\frac{l}{4} = \frac{ml^2}{12}\omega - \frac{mv'l}{4}$$

$$\therefore\ mu\frac{l}{4} = \frac{ml^2}{12}\omega \Rightarrow u = \frac{\omega l}{3}$$

$$\Rightarrow\ u = \frac{24v}{55},\ \omega = \frac{72v}{55l}$$

Time taken to rotate by π angle, $t = \frac{\pi}{\omega}$

In the same time, distance travelled $= ut = \frac{\pi l}{3}$

Using impulse-momentum equation on the rod

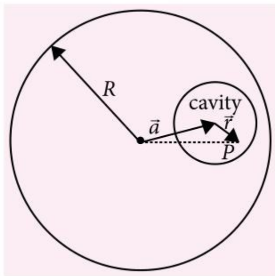
$$\int N dt = mu = \frac{24mv}{55}$$

6. (a, c) : Let us consider first the gravitational field inside a sphere of density ρ. At a radius x, the gravitational field is equal to the field due to the mass contained within radius x,

$$\therefore\ g = \frac{G\frac{4}{3}\pi x^3\rho}{x^2} = \frac{4\pi G\rho x}{3},$$

and since the field is directed radially inwards, we can write this in vector form as $\vec{g} = -\frac{4}{3}\pi G\rho\vec{x}$

Now we can consider the sphere with a spherical cavity as shown in figure.



Consider a point P within the cavity such that the vector displacement of P from the centre of the cavity is $\vec{r}$. The vector displacement of P from the centre of the original sphere is thus $\vec{a} + \vec{r}$, and the gravitational field at P due to the original sphere is

$$-\frac{4}{3}\pi G\rho(\vec{a} + \vec{r})$$

The gravitational field due to the material removed to make the cavity is

$$-\frac{4}{3}\pi G\rho\vec{r},$$

so the total gravitational field at P is

$$\vec{g} = -\frac{4}{3}\pi G\rho(\vec{r}+\vec{a})+\frac{4}{3}\pi G\rho\vec{r} = -\frac{4}{3}\pi G\rho\vec{a}.$$

The field within the cavity is thus uniform. Its magnitude is $4\pi G\rho a/3$ (*i.e.*, depends only on the position, and not the size, of the cavity) and its direction is parallel to the line joining the center of the cavity to the centre of the original space.

7. (b, c) : Thermal force = $YA\alpha d\theta = Y\pi r^2\alpha d\theta$

$r_1 = r,\ r_2 = r\sqrt{2},\ r_3 = r\sqrt{3},\ r_4 = 2r$

$F_1 : F_2 : F_3 : F_4 = 1 : 2 : 3 : 4$

Thermal stress = $Y\alpha d\theta$

As Y and α are same for all the rods, hence stress developed in each rod will be the same. As strain = $\alpha d\theta$, so strain will also be the same.

E = Energy stored

$$= \frac{1}{2}Y(\text{strain})^2 \times A \times L$$

$\therefore\ E_1 : E_2 : E_3 : E_4 = 1 : 2 : 3 : 4$

So, option (b) and (c) are correct.

8. (4): Let R be the radius of the semicircle. Then $\pi R + 2R = l$ or $R = \dfrac{l}{2+\pi}$.

The magnetic field at the centre of the semicircle = field due to circular part + field due to diametrical part

$$B = \frac{\mu_0 I}{4R}+0 = \frac{\mu_0 I}{4l}(2+\pi)$$

$\because\ \Delta F = I\Delta lB\sin\theta$

$$\frac{\Delta F}{\Delta l} = I\left[\frac{\mu_0 I(2+\pi)}{4l}\right] = \frac{\mu_0 I^2(2+\pi)}{4l}$$

$$\therefore\ \frac{\Delta F}{\Delta l} = \frac{4\pi\times10^{-7}\times8^2(2+\pi)}{4\times1} = 1.03\times10^{-4}\text{ N}$$

$\therefore\ x = 4$

9. (6): Velocity of the centre = v_0 and the angular velocity about the centre = $\dfrac{v_0}{2r}$. Thus, $v_0 > \omega_0 r$. The sphere slips forward and thus the friction by the plane on the sphere will act backward. As the friction is kinetic, its value is $\mu N = \mu Mg$ and the sphere will be decelerated by $a_{CM} = f/M$.

$$\therefore\ v(t) = v_0 - \frac{f}{M}t \quad \text{...(i)}$$

This friction will also produce a torque $\tau = fr$ about the centre. This torque is clockwise and in the direction of ω_0. Hence the angular acceleration about the centre will be

$$\alpha = f\frac{r}{(2/5)Mr^2} = \frac{5f}{2Mr}$$

and the clockwise angular velocity at time t will be

$$\omega(t) = \omega_0 + \frac{5f}{2Mr}t = \frac{v_0}{2r}+\frac{5f}{2Mr}t$$

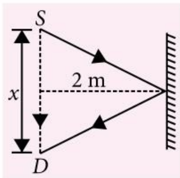
Pure rolling starts when $v(t) = r\omega(t)$

$$i.e.,\ v(t) = \frac{v_0}{2}+\frac{5f}{2M}t \quad \text{...(ii)}$$

From eqn. (i) and (ii),

$$v(t) = \frac{2}{7}\times3v_0 = \frac{6}{7}v_0 = \frac{nv_0}{7} \quad \therefore\ n = 6$$

10. (3): The situation is shown in figure. Suppose the detector is placed at a distance of x m from the source. The direct wave received from the source travels a distance of x meter. The wave reaching the detector after reflection from the wall has travelled a distance of $2[(2)^2 + x^2/4]^{1/2}$ m. The path difference between the two waves is



$$\Delta = \left\{2\left[(2)^2+\frac{x^2}{4}\right]^{1/2} - x\right\}\text{m}$$

Constructive interference will take place when $\Delta = \lambda, 2\lambda, ...$

The minimum distance x for a maximum sound corresponds to $\Delta = \lambda$ ...(i)

$$\text{The wavelength is } \lambda = \frac{v}{\upsilon} = \frac{360\text{ m s}^{-1}}{180\text{ s}^{-1}} = 2\text{ m.}$$

$$\text{Thus, from eqn. (i), } 2\left[(2)^2+\frac{x^2}{4}\right]^{1/2} - x = 2$$

$$\Rightarrow \left[4+\frac{x^2}{4}\right]^{1/2} = 1+\frac{x}{2} \quad \therefore\ x = 3\text{ m}$$

Thus, the detector should be placed at a distance of 3 m from the source.

11. (1): Here $qE = qvB\sin\phi$ or $v = \dfrac{E}{B\sin\phi}$

$v' = v\cos\phi$ = velocity along the field

$v'' = v\sin\phi$ = velocity perpendicular to field

By the dynamics of circular motion

$$qv''B = \frac{mv''^2}{r} \text{ or } qB = m\omega \text{ or } T = \frac{2\pi m}{qB}$$

$$\therefore\ p = T\times v\cos\phi = \frac{2\pi m}{qB}v\cos\phi = \frac{2\pi m}{qB}\left(\frac{E}{B\sin\phi}\right)\cos\phi$$

or $p = \dfrac{2\pi mE}{qB^2}\cot\phi = \dfrac{2\pi\times 1.67\times 10^{-27}\times 4.5\times 10^4}{1.6\times 10^{-19}\times 40^2\times 10^{-6}}\cot 60°$

≈ 1 m

12. (6) : We have, $N = N_0 e^{-\lambda t}$ ...(i)

The activity of the sample is given by

$$\frac{dN}{dt} = -\lambda N_0 e^{-\lambda t} = -\lambda N$$

i.e., activity is proportional to the number of undecayed nuclei.

At $t = 0$, $\left(\dfrac{dN}{dt}\right)_{t=0} = -\lambda N_0$

At $t = 5$ min, $\left(\dfrac{dN}{dt}\right)_{t=5\text{ min}} = -\lambda N$

$$\therefore \quad \frac{N_0}{N} = \frac{\left(\frac{dN}{dt}\right)_{t=0}}{\left(\frac{dN}{dt}\right)_{t=5\text{ min}}} = \frac{4750}{2700} = 1.760$$

From eqn. (i), we have

$$\frac{N}{N_0} = e^{-\lambda t} \quad \text{or} \quad \frac{N_0}{N} = e^{\lambda t} \quad \text{or} \quad \ln\frac{N_0}{N} = \lambda t$$

$$\Rightarrow \lambda = \frac{1}{t}\ln\frac{N_0}{N} = \frac{2.3026}{t}\times\log_{10}\left(\frac{N_0}{N}\right)$$

Substituting the given values, we have

$$\lambda = \frac{2.3026}{5}\times 0.2455 = 0.113\ \text{min}^{-1}$$

Half-life of sample, $T = \dfrac{0.6931}{\lambda} = \dfrac{0.6931}{0.113} = 6.1$ min

13. (b), 14. (d), 15 (a)

Using lens maker's formula,

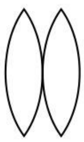
$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Here, $\mu = 1.5$

(i) $R_1 = r, R_2 = -r$

$$\therefore \quad \frac{1}{f} = (1.5-1)\left(\frac{1}{r}+\frac{1}{r}\right) = (0.5)\left(\frac{2}{r}\right)$$

$\Rightarrow f = r$



So, $\dfrac{1}{f'} = \dfrac{1}{f_1} + \dfrac{1}{f_2} = \dfrac{1}{r} + \dfrac{1}{r} = \dfrac{2}{r}$

$\Rightarrow f' = (r/2)$.

(ii) $R_1 = \infty, R_2 = -r$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{\infty}+\frac{1}{r}\right) = \frac{0.5}{r} = \frac{1}{2r}$$

$\Rightarrow f = 2r$

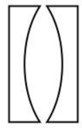
So, $\dfrac{1}{f'} = \dfrac{1}{f} + \dfrac{1}{f} = \dfrac{2}{f} = \dfrac{2}{2r}$

$\Rightarrow f' = r$

(iii) $R_1 = \infty, R_2 = r$

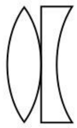
$$\frac{1}{f} = (1.5-1)\left(\frac{1}{\infty}-\frac{1}{r}\right) = -\frac{1}{2r}$$

$\Rightarrow f = -2r$



So, $\dfrac{1}{f'} = \dfrac{1}{f} + \dfrac{1}{f} = \dfrac{2}{f} = \dfrac{2}{-2r} \Rightarrow f' = -r$

(iv) $\dfrac{1}{f'} = \dfrac{1}{f_1} + \dfrac{1}{f_2} = \dfrac{1}{r} + \dfrac{1}{-2r} = \dfrac{1}{2r}$



$\Rightarrow f' = 2r$

For myopic eye, person cannot see far-off objects clearly. To correct such defect of vision, a concave lens must be used whose focal length is equal to the far point of myopic eye.

$\therefore$ $u = \infty, f = v$ and image formed by this lens is virtual and smaller. The correct combination is

IV $\rightarrow$ iii $\rightarrow$ Q

Image of the object is formed at infinity if the object is placed at focus of the lens. Image formed is very large and real in case of convex lens.

So option (d) is correct for question no. 14.

$$\text{Magnification} = \frac{\text{Image distance}}{\text{Object distance}}$$

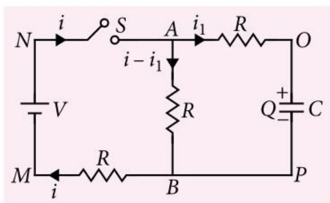
For convex lens : If $2f < u < f$ then $v > 2f$ then image formed will be larger and real.

If u is between focus and pole then image will be larger and virtual.

So option (a) is correct for question no. 15.

16. (c), 17. (b), 18 (d)

Let at any time t charge on capacitor C be Q and currents are as shown in the figure. Since, charge Q will increase with time t.



Applying Kirchhoff's second law in loop $MNABM$

$$V = (i - i_1)R + iR$$

or $V = 2iR - i_1R$ ...(i)

Similarly, applying Kirchhoff's second law in loop $MNOPM$, we have

$$V = i_1 R + \frac{Q}{C} + iR \quad \text{...(ii)}$$

Eliminating i from eqns. (i) and (ii), we get

$$V = 3i_1 R + \frac{2Q}{C}$$

or $3i_1 R = V - \frac{2Q}{C}$ or $i_1 = \frac{1}{3R}\left(V - \frac{2Q}{C}\right)$

or $\frac{dQ}{dt} = \frac{1}{3R}\left(V - \frac{2Q}{C}\right)$ or $\frac{dQ}{V - \frac{2Q}{C}} = \frac{dt}{3R}$

or $\int_0^Q \frac{dQ}{V - \frac{2Q}{C}} = \int_0^t \frac{dt}{3R}$

This equation gives charge on capacitor at any time t

$$Q = \frac{CV}{2}(1 - e^{-2t/3RC}) \quad \text{...(iii)}$$

$$i_1 = \frac{dQ}{dt} = \frac{V}{3R} e^{-2t/3RC}$$

From eqn. (i)

$$i = \frac{V + i_1 R}{2R} = \frac{V + \frac{V}{3}e^{-2t/3RC}}{2R}$$

$\therefore$ Current through AB

$$I = i - i_1 = \frac{V + \frac{V}{3}e^{-2t/3RC}}{2R} - \frac{V}{3R}e^{-2t/3RC}$$

$$I = \frac{V}{2R} - \frac{V}{6R}e^{-2t/3RC} \quad \text{...(iv)}$$

At $t = 0$,

$$Q_0 = \frac{cV}{2}(1 - e^{-0}) = 0$$

$$I = \frac{V}{2R} - \frac{V}{6R}(e^{-0}) = \frac{V}{2R} - \frac{V}{6R} = \frac{V}{3R}$$

At $t = \frac{3RC}{2} = \tau_c$

$$Q = \frac{CV}{2}(1 - e^{-1}) = \frac{CV}{2}\left(1 - \frac{1}{e}\right)$$

$$I = \frac{V}{2R} - \frac{V}{6R}(e^{-1}) = \frac{V}{R}\left(\frac{1}{2} - \frac{1}{6e}\right)$$

When $t = 5\tau_c = \frac{15RC}{2}$

$$Q = \frac{CV}{2}(1 - e^{-5}) = 99.99\left(\frac{CV}{2}\right) \approx \frac{CV}{2}$$

$$I = \frac{V}{2R} - \frac{V}{6R}(e^{-5}) \approx \frac{V}{2R}$$

This situation corresponds to time $t = \infty$ *i.e.*, $Q = \frac{CV}{2}$ and $I = \frac{V}{2R}$.

PAPER-2

1. (d): Here, $n = 2$,

For isochoric process, $P \propto T$

$$\therefore \frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow T_2 = \frac{P_2}{P_1} \times T_1 = \frac{T_1}{2} \quad \left(\because \frac{P_2}{P_1} = \frac{1}{2}\right)$$

Now from first law of thermodynamics

$$Q_1 = \Delta U_1 = \frac{nR\Delta T}{\gamma - 1} = \frac{2R}{\gamma - 1}\left(\frac{T_1}{2} - T_1\right) = \frac{-RT_1}{(\gamma - 1)}$$

During the second case (*i.e.*, isobaric process),

$\Delta W_2 = P\Delta V = nR\Delta T$

Thus from first law of thermodynamics :

$$Q_2 = \Delta U_2 + \Delta W_2 = \frac{nR\Delta T'}{\gamma - 1} + nR\Delta T'$$

$$= nR\Delta T'\left(\frac{1}{\gamma - 1} + 1\right) = 2R\left(T_1 - \frac{T_1}{2}\right)\left(\frac{\gamma}{\gamma - 1}\right)$$

$$= \frac{R\gamma T_1}{(\gamma - 1)}$$

Hence the total amount of heat absorbed

$Q = Q_1 + Q_2 = RT_1 = 300\ R$

2. (b) : The escape velocity from the surface of a planet is

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2 \cdot G\rho \frac{4}{3}\pi R^3}{R}}$$

($\because$ ρ is same for all planet)

$v_e \propto R$ ...(i)

Surface area of P, $4\pi R_P^2 = A$

Surface area of Q, $4\pi R_Q^2 = 4A$

$$\therefore \frac{R_P}{R_Q} = \frac{1}{2} \Rightarrow R_Q = 2R_P$$

The spherical planet W has mass

$M_W = M_P + M_Q$

$$\therefore \frac{4}{3}\rho\pi R_W^3 = \frac{4}{3}\rho\pi R_P^3 + \frac{4}{3}\rho\pi R_Q^3 \Rightarrow R_W^3 = R_P^3 + R_Q^3$$

or $R_W^3 = R_P^3 + (2R_P)^3$

So, $R_W = (9)^{1/3} R_P$

Therefore, $R_W > R_Q > R_P$

From eqn. (i), $v_W > v_Q > v_P$

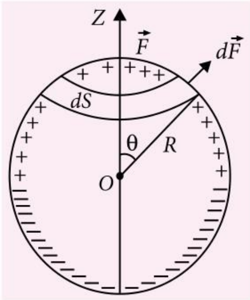
3. (a): An element area $dS = 2\pi R\sin\theta(Rd\theta)$ is shown in figure. The force acting on the area element dS of a conductor is

$$d\vec{F} = \frac{1}{2}\sigma\vec{E}dS \quad \text{...(i)}$$

$\therefore \quad dF_z = dF\cos\theta$ ...(ii)

$$\therefore \quad dF_z = \frac{\pi\sigma^2 R^2}{\varepsilon_0}\sin\theta\cos\theta\, d\theta$$

$$\left(\text{As } E = \frac{\sigma}{\varepsilon_0}\right)$$



$$\int dF_z = \frac{\pi\sigma_0^2 R^2}{\varepsilon_0}\int_0^{\pi/2}\sin\theta\cos^3\theta\, d\theta$$

$$\therefore \quad F = F_z = \frac{\pi\sigma_0^2 R^2}{4\varepsilon_0}$$

4. (b): When the capillary is removed,the liquid comes out with a velocity of v_0. Density of liquid is ρ.
From Bernouilli's theorem,

$$\therefore \quad P + P_0 + \frac{1}{2}\rho v_1^2 + \rho gh = \frac{1}{2}\rho v_0^2 + P_0$$

or $P + \rho gh = \frac{\rho}{2}(v_0^2 - v_1^2)$ ...(i)

By equation of continuity,

$A_1 v_1 = A_2 v_0$, where $A_1 = \frac{\pi D^2}{4}$, $A_2 = \frac{\pi d^2}{4}$.

or $v_1 = \left(\frac{d}{D}\right)^2 v_0$ ...(ii)

From eqn. (i) and (ii), eliminate v_1

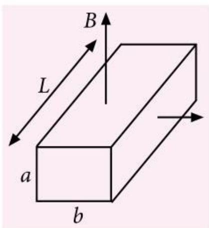
$$\therefore \quad P + \rho gh = \frac{\rho}{2}\left[v_0^2 - \left(\frac{d^2}{D^2}v_0\right)^2\right]$$

or $P + \rho gh = \frac{\rho v_0^2}{2}\left[1 - \frac{d^4}{D^4}\right]$ or $\Delta P = \frac{\rho v_0^2}{2}\left[1 - \frac{d^4}{D^4}\right]$

By Poiseuille's equation, $Q = \frac{\pi(\Delta P)a^4}{8\eta l}$

or $\eta = \frac{\pi(\Delta P)a^4}{8Ql}$ or $\eta = \frac{\pi}{8Ql} \times \frac{\rho v_0^2}{2}\left(1 - \frac{d^4}{D^4}\right)a^4$

5. (a) : The current density is $\frac{I}{aL}$, where L is the length of the section. The difference in pressure produced must be,



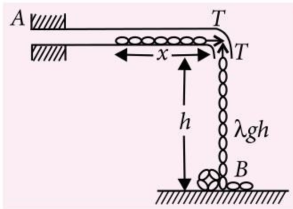
$$\Delta P = \frac{\frac{I}{aL}\times B \times (abL)}{ab} = \frac{IB}{a}$$

$$= \frac{100 \times 0.10}{2\times 10^{-2}} = 500 \text{ N}$$

6. (c) : Let the length of the chain inside the smooth horizontal tube at an arbitrary instant is x.
From the equation of motion

$$ma = F + u\frac{dm}{dt}$$

As $u = 0$, $F = ma$



or $\lambda x a = T$ where $\lambda = \frac{m}{l}$ (Since $F = T$) ...(i)

Similarly for the overhanging part, $u = 0$
Thus, $ma = F$
or $\lambda h a = \lambda h g - T$ ...(ii)
From eqns. (i) and (ii)

$\lambda(x + h)a = \lambda hg$ or, $(x + h)v\frac{dv}{ds} = hg$ $\left(\because a = v\frac{dv}{ds}\right)$

or $(x + h)v\frac{dv}{(-dx)} = gh,$

[As the length of the chain inside the tube decreases with time, $ds = -dx$.]

or $vdv = -gh\frac{dx}{x+h}$

Integrating $\int_0^v vdv = -gh\int_{(l-h)}^{0}\frac{dx}{x+h}$

or $\frac{v^2}{2} = gh\ln\left(\frac{l}{h}\right)$ or $v = \sqrt{2gh\ln\left(\frac{l}{h}\right)}$

7. (b): The loops are connected in such a way that if the current is clockwise in one, it is anticlockwise in the other. Hence the e.m.f. in smaller loop opposes the e.m.f in larger loop

e.m.f in larger loop $= \frac{d}{dt}(a^2 B) = a^2\frac{d}{dt}(B_0\sin\omega t)$

$$= a^2\omega B_0\cos\omega t$$

Similarly, e.m.f. in smaller loop = $b^2 B_0\,\omega\cos\omega t$.
Hence, net e.m.f in the circuit = $(a^2 - b^2)B_0\,\omega\cos\omega t$, as both the e.m.fs are in opposite sence, and resistance of the circuit = $4(a + b)\rho$

Therefore, the amplitude of the current, $I = \frac{(a^2 - b^2)B_0\omega}{4(a+b)\rho}$

Since a = 20 cm = 0.2 m; b = 10 cm = 0.1 m, $P = 0.05\ \Omega\text{m}^{-1}$
B_0 = 10 mT = 10^{-2} T and ω = 100 rad s^{-1}
$\therefore \quad I = 0.5$ A

8. (a, c)

9. (a, b, d) : (a) According to Einstein's photoelectric equation

Incident Energy = work function + Maximum kinetic energy of the photoelectron

or $E = (1.82 + 0.73)$ eV

or $E = 2.55$ eV

(b) In case of hydrogen atom, $E_n = -(13.6/n^2)$.

$\therefore$ $E_1 = -13.6$ eV, $E_2 = -3.4$ eV, $E_3 = -1.5$ eV, $E_4 = -0.85$ eV.

The discharge tube contains hydrogen atoms.

Since $E_4 - E_2 = -0.85 - (-3.4) = 2.55$ eV

Hence the quantum numbers of the two levels involved in the emission of these photons are 4 and 2.

The transition occurs from $n = 4$ to $n = 2$

(c) Change in angular momentum in above transition,

$\Delta L = L_2 - L_4$

$$\text{or} \quad \Delta L = 2\left(\frac{h}{2\pi}\right) - 4\left(\frac{h}{2\pi}\right) \quad \text{or} \quad \Delta L = \frac{-h}{\pi}$$

(d) Momentum is conserved in the process.

Momentum of hydrogen atom = mv

Momentum of emitted photon $= \dfrac{E}{c}$

$$\therefore \quad mv = \frac{E}{c}$$

$$\text{or} \quad v = \frac{E}{mc} \quad \text{or} \quad v = \frac{2.55 \times 1.6 \times 10^{-19}}{(1.67 \times 10^{-27})(3 \times 10^{8})}$$

or $v = 0.814$ m s^{-1}

$\therefore$ Recoil speed of emitting atom = 0.814 m s^{-1}.

10. (b, c) : Velocity and acceleration for a particle executing S.H.M. are given by the expressions

$$v^2 = \omega^2(A^2 - x^2)$$

and $a = -\omega^2 x$

Let the particle be at positions x_1 and x_2 at the given instant.

$$u^2 = \omega^2(A^2 - x_1^2) \quad \text{...(i)}$$

$$v^2 = \omega^2(A^2 - x_2^2) \quad \text{...(ii)}$$

$$\alpha = \omega^2 x_1 \quad \text{...(iii)}$$

$$\beta = \omega^2 x_2 \quad \text{...(iv)}$$

Subtracting eqn, (ii) from eqn. (i),

$$u^2 - v^2 = \omega^2(x_2^2 - x_1^2) \quad \text{...(v)}$$

Adding eqns (iii) and (iv),

$$\alpha + \beta = \omega^2(x_1 + x_2)$$

Dividing eq. (v) by eqn. (vi),

$$\frac{u^2 - v^2}{\alpha + \beta} = x_2 - x_1 = x$$

which is separation between particles at the given instant.

From eqns. (iii) and (iv), we obtain

$$\beta - \alpha = \omega^2(x_2 - x_1) \quad \Rightarrow \quad \omega^2 = \frac{\beta - \alpha}{(x_2 - x_1)}$$

$$\text{Time period } T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\dfrac{(\beta-\alpha)}{(x_2 - x_1)}}} = 2\pi\sqrt{\left(\frac{x_2 - x_1}{\beta - \alpha}\right)}$$

$$= 2\pi\sqrt{\frac{(u^2 - v^2)}{(\alpha+\beta)(\beta-\alpha)}} = 2\pi\sqrt{\frac{u^2 - v^2}{\beta^2 - \alpha^2}}$$

11. (a, c) : First, let us find the total height of ascent. At the beginning and the end of the path the velocity of the body is equal to zero, and therefore the increment in the kinetic energy of the body is also equal to zero. On the other hand, in accordance with work-energy theorem ΔK.E. is equal to the algebraic sum of the works W performed by all the forces, *i.e.*, by the force F and gravity, over this path. However, since ΔK.E. = 0, then $W = 0$. Taking into account that the upward direction is assumed to coincide with the positive direction of the y-axis, we can write

$$W = \int(\vec{F} + m\vec{g})\cdot d\vec{r} = \int(2ay - 1)m(\vec{g}\cdot d\vec{r})$$

As $\vec{g}$ acts downwards and $d\vec{r}$ acts upwards.

$$W = mg\int_0^h (1 - 2ay)dy = mgh(1 - ah) = 0$$

Whence $h = 1/a$.

The work performed by the force F over the g first half of the ascent is

$$W_F = \int_0^{h/2} \vec{F}\cdot d\vec{r} = 2mg\int_0^{h/2}(1 - ay)dy = 3mg/4a$$

The corresponding increment of the gravitational potential energy is

$$\Delta U = mgh/2 = mg/2a.$$

12. (a, c) : Let velocity of each observer be u as shown in the figure.

Then frequency received by A will be

$$\upsilon_1 = \upsilon_0\left(\frac{v + u}{v}\right)$$

where υ_0 is natural frequency of the source and v is sound propagation velocity. The frequency received by B will be

$$\upsilon_2 = \upsilon_0\left(\frac{v - u}{v}\right)$$

Since $(\upsilon_1 + \upsilon_2)/2 = \upsilon_0$, therefore option (a) is correct.

13. (b): In a superconductor there is no resistance.

Hence, $L\dfrac{dI}{dt}=+\dfrac{d\phi}{dt}$,

So integrating, $I=\dfrac{\Delta\phi}{L}=\dfrac{\pi a^2 B}{L}$

Because $\Delta\phi=\phi_f-\phi_i$, $\phi_f=\pi a^2 B$, $\phi_i=0$

Also, the work done is, $W=\int \varepsilon I dt=\int\dfrac{d\phi}{dt}I\,dt=\dfrac{1}{2}LI^2$

$$=\frac{\pi^2 a^4 B^2}{2L}$$

14. (a, b, c) : Energy of K absorption edge

$$E_a=\frac{1242\text{ eVnm}}{0.017\text{ nm}}=73.06\times10^3\text{ eV}=73.06\text{ keV}$$

Energy of K_α line is

$$E_{K_\alpha}=\frac{hc}{e\lambda_\alpha}=\frac{1242\text{ eVnm}}{0.021\text{ nm}}=59.14\text{ keV}$$

Similarly, $E_{K_\beta}=\dfrac{1242}{0.0192}=64.69\text{ keV}$

$$E_{K_\gamma}=\frac{1242}{0.0180}=69\text{ keV}$$

Energy of K shell $=(E_{K_\alpha}-E_a)$

$$E_K=(59.14-73.06)\text{ keV}=-13.92\text{ keV}$$

Energy of L shell $=E_{K_\beta}-E_a$

$$E_L=64.69\text{ keV}-73.06\text{ keV}=-8.37\text{ keV}$$

Energy of M shell $=E_{K_\gamma}-E_a$

$$E_M=69\text{ keV}-73.06\text{ keV}=-4.06\text{ keV}$$

15. (c) : Process $1\to2$ (Isochoric process)

$W_{12}=0$

$Q_{12}=\Delta U_{12}=nC_v(T_2-T_1)$

$$=n\frac{3}{2}R(T_2-T_1)=\frac{3}{2}[P_0V_0-(P_0/2)V_0]$$

$$=\frac{3P_0V_0}{4}\text{ (heat absorbed)}$$

Process $3\to1, W_{3\to1}$ = Area under process $3\to1$

$$=-\left(\frac{P_0}{2}+P_0\right)\cdot\frac{V_0}{2}=-\frac{3P_0V_0}{4}$$

Work done during $3\to1$ will be negative as volume is decreasing.

$$\Delta U_{3\to1}=n\frac{3R}{2}(T_1-T_3)=\frac{3}{2}\left(\frac{P_0V_0}{2}-P_2 2V_0\right)=-\frac{9P_0V_0}{4}$$

$Q_{3\to1}=\Delta U_{3\to1}+W_{3\to1}=-3P_0V_0$ (heat rejected)

Process $2\to3$,

The temperature will be maximum at $x=2P_0$,

Since the process in semicircular, volume at $x=(3/2)V_0$

Using ideal gas equation, $T_x=3P_0V_0/2R$

$$W_{2\to x}=W_{x\to3}=\frac{1}{4}\pi\frac{P_0V_0}{2}+\frac{P_0V_0}{2}=\frac{P_0V_0}{2}\left(\frac{\pi}{4}+1\right)$$

$$W_{2\to3}=\frac{P_0V_0}{4}(\pi+4)$$

$$\Delta U_{2\to x}=n\frac{3}{2}R(T_x-T_2)=\frac{3}{2}(3P_0V_0-P_0V_0)=3P_0V_0$$

$$\Delta U_{x\to3}=n\frac{3}{2}R(T_3-T_x)=\frac{3}{2}(2P_0V_0-3P_0V_0)=-\frac{3}{2}P_0V_0$$

$$\therefore\ \Delta Q_{2\to x}=\Delta U_{2\to x}+W_{2\to x}=3P_0V_0+\frac{P_0V_0}{2}\left(\frac{\pi}{4}+1\right)$$

$$=P_0V_0\left(3+\frac{1}{2}+\frac{\pi}{8}\right)=\frac{P_0V_0}{2}\left(7+\frac{\pi}{4}\right)$$

(heat absorbed)

$$\Delta Q_{x\to3}=\Delta U_{x\to3}+W_{x\to3}$$

$$=-\frac{3}{2}P_0V_0+\frac{P_0V_0}{2}\left(\frac{\pi}{4}+1\right)=\frac{-P_0V_0}{2}\left(2-\frac{\pi}{4}\right)$$

(heat released)

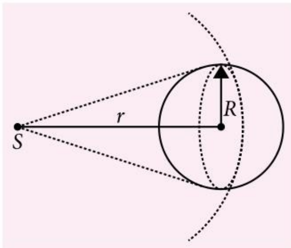
16. (d): Total heat rejected in one cycle

$$=3P_0V_0+\frac{P_0V_0}{2}\left(2-\frac{\pi}{4}\right)=4P_0V_0-\frac{\pi P_0V_0}{8}$$

$$=P_0V_0\left(4-\frac{\pi}{8}\right)=\frac{P_0V_0(32-\pi)}{8}$$

17. (d): If P is the power of point source of light, the intensity at a distance r is

$$I=\frac{P}{4\pi r^2}$$



The energy intercepted by the metallic sphere per second is

E = intensity × projected area of sphere

$$=\frac{P}{4\pi r^2}\times\pi R^2=\frac{PR^2}{4r^2}$$

If E_1 is the energy of the single photon and η the efficiency of the photon to liberate an electron, the number of ejected electron per second is

$$=\eta\frac{PR^2}{4r^2E_1}=\frac{(10^{-6})(3.2\times10^{-3})(8\times10^{-3})^2}{4\times(0.8)^2\times(5\times1.6\times10^{-19})}$$

$$=10^5\text{ electrons s}^{-1}$$

18. (b): The emission of electrons from a metallic sphere leaves it positively charged. As the potential of the charged sphere begins to rise, it attracts emitted electrons. The emission of electrons will stop when the kinetic energy of the electrons is neutralised by the retarding potential of the sphere. So, we have

$$eV=\text{KE}_{\max}\ \Rightarrow\ V=\left(\frac{\text{KE}_{\max}}{e}\right)$$

GEAR UP FOR AIIMS

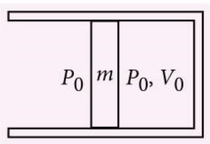
EXAM ON 27TH MAY 2018

1. A solid cylindrical wheel of mass M and radius R is pulled by a force F applied to the centre of the wheel at 37° to the horizontal. If the wheel is to roll without slipping, what is the maximum value of $|F|$? The coefficients of static and kinetic friction are $\mu_s = 0.40$ and $\mu_k = 0.30$ and $\sin 37° = 3/5$.

(a) $0.79\ Mg$ (b) $0.98\ Mg$
(c) $0.6\ Mg$ (d) $0.49\ Mg$

2. A surface will be an equipotential surface, if
(a) electric field is tangential to surface at all the points
(b) electric potential at all the points is non-zero
(c) work done (along any path) in moving a point charge over the surface is non-zero
(d) electrical potential energy of a unit positive charge at any point on the surface will be same.

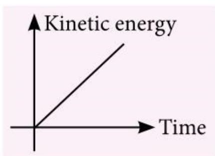
3. A smooth piston of mass m, area of cross-section A is in equilibrium in a gas jar when the pressure of the gas is P_0. When the piston is disturbed slightly, the angular frequency of oscillation of the piston is (Assume adiabatic change of state of the gas and γ is ratio of specific heats of the gas.)

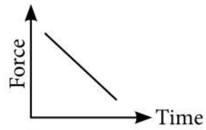


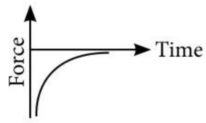
(a) $\sqrt{\dfrac{\gamma P_0 A^2}{3mV_0}}$ (b) $\sqrt{\dfrac{\gamma P_0 A^2}{2mV_0}}$

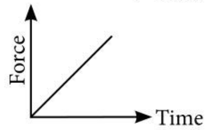
(c) $\sqrt{\dfrac{\gamma P_0 A^2}{mV_0}}$ (d) $\sqrt{\dfrac{2\gamma P_0 A^2}{mV_0}}$

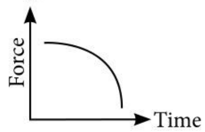
4. The kinetic energy versus time graph for a particle is shown in the figure. The force versus time graph for the particle may be



(a)


(b)


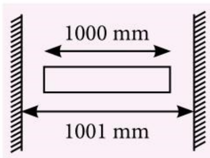
(c)


(d)


5. The capacitors C_1 and C_2 are charged to 120 V and 200 V respectively. It is found that by connecting them together the potential on each one can be made zero. Then,

(a) $5\ C_1 = 3\ C_2$ (b) $3\ C_1 = 5\ C_2$
(c) $5\ C_1 + 3\ C_2 = 0$ (d) $9\ C_1 = 4\ C_2$

6. A rod of length 1000 mm and coefficient of linear expansion $\alpha = 10^{-4}\ °C^{-1}$ is placed symmetrically between fixed walls separated by 1001 mm.



The Young's modulus of the rod is $10^{11}\ N\ m^{-2}$. If the temperature is increased by 20°C, then the stress developed in the rod is

(a) 10^{11} Pa (b) 10^{10} Pa
(c) 10^{9} Pa (d) 10^{8} Pa

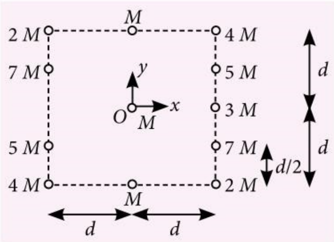
7. A body is projected up with a speed u and the time taken by it is T to reach the maximum height H. Pick out the correct statement.
(a) It reaches height $H/2$ in time $T/2$.
(b) It acquires velocity $u/2$ in time $T/2$.
(c) Its velocity is $u/2$ at $H/2$.
(d) It has same velocity during its journey.

8. An alternating voltage is given by $\varepsilon = \varepsilon_1 \sin \omega t + \varepsilon_2 \cos \omega t$. Then, the root mean square value of voltage is given by

(a) $\sqrt{\varepsilon_1^2 + \varepsilon_2^2}$ (b) $\sqrt{\varepsilon_1 \varepsilon_2}$

(c) $\sqrt{\dfrac{\varepsilon_1 \varepsilon_2}{2}}$ (d) $\sqrt{\dfrac{\varepsilon_1^2 + \varepsilon_2^2}{2}}$

9. For the arrangement as shown in the figure, find the magnitude and direction of the net gravitational force acting on the central particle at O, with respect to the axes is



(a) $\dfrac{3GM^2}{d^2}\hat{i}$ (b) $\dfrac{3GM^2}{d^2}\hat{j}$

(c) $\dfrac{3GM^2}{d^2}(\hat{i}+\hat{j})$ (d) $\dfrac{3GM^2}{d^2}(-\hat{i}-\hat{j})$

10. Molar heat capacity for an ideal gas

(a) is infinity for adiabatic process

(b) is zero for isothermal process

(c) is independent of the nature of the gas for a process in which either volume or pressure is constant

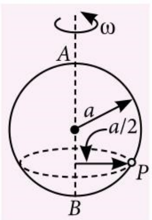
(d) is equal to the product of molecular weight and specific heat capacity for any process.

11. A boat crosses a river of width 1 km in shortest path in 15 minutes. If the speed of boat in still water is 5 km h^{-1}, then what is the speed of the river?

(a) 1 km h^{-1} (b) 3 km h^{-1}

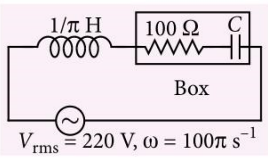
(c) 2 km h^{-1} (d) 5 km h^{-1}

12. A smooth wire is bent into a vertical circle of radius a. A bead P can slide smoothly on the wire. The circle is rotated about vertical diameter AB as axis with a speed ω as shown in figure. The bead P is at rest w.r.t. the circular ring in the position shown. Then ω^2 is equal to



(a) $\dfrac{2g}{a}$ (b) $\dfrac{2g}{a\sqrt{3}}$ (c) $\dfrac{g\sqrt{3}}{a}$ (d) $\dfrac{2a}{g\sqrt{3}}$

13. For the circuit as shown in figure, if the value of rms current is 2.2 A, the power factor of the box is



(a) $\dfrac{1}{\sqrt{2}}$ (b) 1

(c) $\dfrac{\sqrt{3}}{2}$ (d) $\dfrac{1}{2}$

14. An object weighs m_1 in a liquid of density ρ_1 and that in liquid of density ρ_2 is m_2. The density ρ of the object is

(a) $\rho = \dfrac{m_2\rho_2 - m_1\rho_1}{m_2 - m_1}$ (b) $\rho = \dfrac{m_1\rho_1 - m_2\rho_2}{m_2 - m_1}$

(c) $\rho = \dfrac{m_2\rho_1 - m_1\rho_2}{m_1 - m_2}$ (d) $\rho = \dfrac{m_1\rho_2 - m_2\rho_1}{m_1 - m_2}$

15. A car is moving along a road with a speed of 45 km h^{-1}. In what direction must a body be projected from it with a velocity of 25 m s^{-1}, so that its resultant motion is at right angles to the direction of car?

(a) At an angle of 120° with the direction of motion of car.

(b) At an angle of 60° with the direction of motion of car.

(c) At an angle of 90° with the direction of motion of car.

(d) At an angle of 135° with the direction of motion of car.

16. A wire of length l is moving with velocity v at an angle θ in the region of a uniform magnetic field B such that length of the wire always remains perpendicular to field lines. The induced emf in wire is

(a) 0 (b) $l(\vec{v}\cdot\vec{B})$

(c) $l(\vec{v}\times\vec{B})$ (d) $l(\vec{B}\times\vec{v})$

17. Two metal spheres are falling through a liquid of density 2×10^3 kg m^{-3} with the same uniform speed. The density of sphere 1 and sphere 2 are 8×10^3 kg m^{-3} and 11×10^3 kg m^{-3} respectively. The ratio of their radii is

(a) $\dfrac{11}{8}$ (b) $\sqrt{\dfrac{11}{8}}$ (c) $\dfrac{3}{2}$ (d) $\sqrt{\dfrac{3}{2}}$

18. A particle of mass m moves in potential energy field given by $U = bx^2 - ax$, where a and b are positive constants. The frequency of oscillation of the particle is

(a) $\dfrac{1}{2\pi}\sqrt{\dfrac{2b}{m}}$ (b) $\dfrac{2}{\pi}\sqrt{\dfrac{b}{m}}$

(c) $\dfrac{1}{\pi}\sqrt{\dfrac{b}{2m}}$ (d) $\dfrac{1}{\pi}\sqrt{\dfrac{b}{m}}$

19. An express train is moving with a velocity v_1. Its driver finds another train is moving on the same track in the same direction with velocity v_2. To escape collision, driver applies a retardation a on the train. The minimum time of escaping collision will be

(a) $t = \frac{v_1 - v_2}{a}$ (b) $t = \frac{\sqrt{v_1^2 - v_2^2}}{2a}$

(c) $t = \frac{v_1 + v_2}{a}$ (d) $t = \frac{\sqrt{v_1^2 + v_2^2}}{a}$

20. A wire of length L and 3 identical cells of negligible internal resistance are connected in series. Due to the current, the temperature of the wire is raised by ΔT in a time t. N similar cells is now connected in series with a wire of the same material and cross-section but of length $2L$. The temperature of the wire is raised by the same amount ΔT in the same time t. The value of N is

(a) 4 (b) 6 (c) 8 (d) 9

21. A thermometer has wrong calibrations. It reads melting point of ice as –10°C and reads 60°C at a temperature of 50°C. Temperature of boiling point noted by this thermometer will be

(a) 120 °C (b) 110 °C (c) 90 °C (d) 130 °C

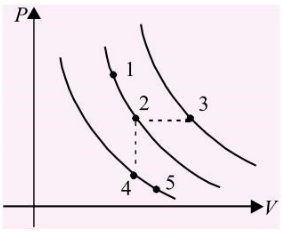
22. A body of mass 60 kg is resting in a lift which accelerates upwards with acceleration 2 m s^{-2}. The apparent weight is [Take g = 10 m s^{-2}]

(a) 72 N (b) 60 N (c) 48 N (d) 720 N

23. A long straight wire of circular cross-section is made of a non-magnetic material. The wire has radius R. The wire carries a current I which is uniformly distributed over its cross-section. The energy stored per unit length in the magnetic field contained within the wire is

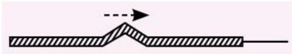
(a) $\frac{\mu_0 I^2}{8\pi}$ (b) $\frac{\mu_0 I^2}{16\pi}$ (c) $\frac{\mu_0 I^2}{4\pi}$ (d) $\frac{\mu_0 I^2}{2\pi}$

24. A certain gas is taken to the five states represented by dots in the graph. The plotted lines are isotherms. Order of the most probable speed v_p of the molecules at these five states is



(a) $v_{p \text{ at } 3} > v_{p \text{ at } 1} = v_{p \text{ at } 2} > v_{p \text{ at } 4} = v_{p \text{ at } 5}$
(b) $v_{p \text{ at } 1} > v_{p \text{ at } 2} = v_{p \text{ at } 3} > v_{p \text{ at } 4} = v_{p \text{ at } 5}$
(c) $v_{p \text{ at } 3} > v_{p \text{ at } 2} = v_{p \text{ at } 4} > v_{p \text{ at } 1} = v_{p \text{ at } 5}$
(d) insufficient information to predict the result.

25. The pulse in the figure shown has a speed of 0.1 m s^{-1}. The linear mass density of the right string is 0.25 that of the left string. At what speed does the transmitted wave travel?



(a) 25 cm s^{-1} (b) 20 cm s^{-1}
(c) 15 cm s^{-1} (d) 17.5 cm s^{-1}

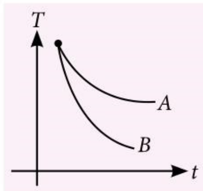
26. An ideal gas heat engine operates in Carnot cycle between 227°C and 127°C. It absorbs 6 × 10^4 cal heat at higher temperature. Amount of heat converted into work is

(a) 4.8 × 10^4 cal (b) 2.4 × 10^4 cal
(c) 1.2 × 10^4 cal (d) 6 × 10^4 cal

27. A nichrome heating element connected across 230 V supply consumes 1.5 kW of power and heats upto a temperature of 750°C. A tungsten bulb across the same supply operates at much higher temperature of 1600°C. In order to emit light the

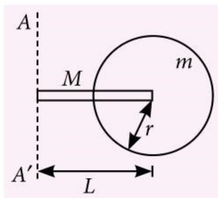
(a) power of bulb is much higher than that of heating element
(b) power of heating element is more than that of bulb
(c) power of both is nearly same
(d) data is insufficient to reach any conclusion

28. Variation of temperature T of two identical bodies A and B with time t, when they loose heat by radiation only is as shown in the figure. Then, correct relation between emissivity (e) and absorptivity (a) of the two bodies is



(a) $e_A > e_B$ and $a_A < a_B$
(b) $e_A < e_B$ and $a_A > a_B$
(c) $e_A > e_B$ and $a_A > a_B$
(d) $e_A < e_B$ and $a_A < a_B$

29. Find the moment of inertia of a system having a spherical ball of mass m and radius r attached at the end of a thin straight rod of mass M and length L, about the AA' shown in the figure.



(a) $\frac{L^2}{2}\left(m + \frac{M}{3}\right) + \frac{1}{5}mr^2$

(b) $L^2\left(m + \frac{M}{3}\right) + \frac{2}{5}mr^2$

(c) $\frac{2L^2}{3}\left(m + \frac{M}{3}\right) + \frac{2}{5}mr^2$

(d) None of these

30. A spaceship is launched into a circular orbit close to the earth's surface. The additional velocity now to be imparted to the spaceship in the orbit to overcome the gravitational pull is

(a) $\sqrt{2}gR$ (b) $(\sqrt{2}+1)\sqrt{gR}$
(c) $\sqrt{2gR}$ (d) $(\sqrt{2}-1)\sqrt{gR}$

31. Let there are two bulbs in your house, one is red and other one is blue. Both bulbs are of same power. If n_r and n_b are the number of photons per second reaching towards you in a certain time, then

(a) $n_r = n_b$ (b) $n_r > n_b$
(c) $n_r < n_b$ (d) $n_r \cdot n_b = c^2$

32. The mean free path of a gas molecule at STP is 2.1×10^{-7} m. Find the diameter of the molecule. (Boltzmann constant = 1.4×10^{-23} J K^{-1})

(a) 5.2 Å (b) 4.6 Å (c) 3.5 Å (d) 2.0 Å

33. The mobility of free electrons (charge e, mass m and relaxation time τ) in a metal is proportional to

(a) $\frac{e}{m}\tau$ (b) $\frac{m}{e}\tau$ (c) $\frac{e}{m\tau}$ (d) $\frac{m}{e\tau}$

34. A charged particle moves with a velocity $\vec{v} = a\hat{i} + d\hat{j}$ in a magnetic field $\vec{B} = A\hat{i} + D\hat{j}$. The force acting on the particle has magnitude of

(a) $F = 0$, if $aD = dA$ (b) $F = 0$, if $aD = -dA$
(c) $F = 0$, if $aA = -dD$
(d) $F \propto (a^2 + b^2)^{1/2} \times (A^2 + D^2)^{1/2}$

35. In a common emitter configuration of a transistor, the voltage drop across a 500 Ω resistor in the collector circuit is 0.5 V when the collector supply voltage is 5 V. If the current gain in the common base mode is 0.96, the base current is

(a) $\frac{1}{20}$ μA (b) $\frac{1}{5}$ μA
(c) $\frac{1}{20}$ mA (d) $\frac{1}{24}$ mA

36. A wheel with 30 metallic spokes each of 0.7 m long is rotated with a speed of 120 rpm, in a plane normal to the horizontal component of earth's magnetic field H_E at a place. If H_E = 0.8 G at the place, what is the induced emf between the axle and the rim of the wheel? (Given 1 G = 10^{-4} T)

(a) 2.46×10^{-4} V (b) 6.28×10^{-4} V
(c) 5.76×10^{-5} V (d) 4.92×10^{-4} V

37. Let r be the distance of a point on the axis of a bar magnet of length 2 l from its centre ($r >>> l$). The magnetic field at such a point is proportional to

(a) $\frac{1}{r}$ (b) $\frac{1}{r^2}$
(c) $\frac{1}{r^3}$ (d) None of these

38. A stone of relative density K is released from rest on the surface of a lake. If viscous effects are ignored, the stone sinks in water with an acceleration of

(a) $g(1 - K)$ (b) $g(1 + K)$
(c) $g\left(1-\frac{1}{K}\right)$ (d) $g\left(1+\frac{1}{K}\right)$

39. An α-particle moving horizontally makes a head on collision elastically with a proton (at rest). What are the ratio of de-Broglie's wavelength's associated with α-particle and proton just after collision?

(a) 2 : 1 (b) 4 : 3 (c) 1 : 2 (d) 2 : 3

40. Two identical positive point charges Q each are fixed at a distance $d = 2a$ apart in air. A point charge $-q$ lies at mid-point on the line joining the charges. If $-q$ is given a very small lateral displacement, the frequency of oscillation is

(a) $\frac{1}{2\pi}\sqrt{\frac{Qq}{2\pi\varepsilon_0 ma^3}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{Qq}{4\pi\varepsilon_0 ma^3}}$
(c) $\frac{1}{\pi}\sqrt{\frac{Qq}{\pi\varepsilon_0 ma^3}}$ (d) $\frac{1}{\pi}\sqrt{\frac{2Qq}{\pi\varepsilon_0 ma^3}}$

Directions : In the following questions (41-60), a statement of assertion is followed by a statement of reason. Mark the correct choice as

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

41. **Assertion :** Ionisation energy of isolated pentavalent atom of phosphorus is very large so, in a n-type semiconductor, there are no free charge carries at room temperature.

Reason : When current flows through a p-n junction diode, it becomes hot.

42. **Assertion :** A point particle of mass m moving with speed v collides with stationary point particle of mass M. If the maximum energy loss possible is given as $k\left(\frac{1}{2}mv^2\right)$ then $k = \left(\frac{M}{M+m}\right)$.

Reason : Maximum energy loss occurs when the particles get struck together as a result of the collision.

43. Assertion : When the displacement of a body is directly proportional to the square of the time. The the body is moving with uniform acceleration.
Reason : The slope of velocity-time graph with time axis given acceleration.

44. Assertion : When stream of α-particles (obtained from a decaying radioactive sample) is made to pass through a region of perpendicular magnetic field, they follow circular paths of some fixed values of radius.
Reason : Some of the daughter nuclei may be produced in their excited states.

45. Assertion : A solid body of density half that of water, falls from a height of 10 m and then enters into water. The depth to which it will go in water is 10 m.
Reason : Depth in water is equal to height from which the body falls.

46. Assertion : When a body is dropped from a height explodes in mid air, but its centre of mass keeps moving in vertically downward direction.
Reason : Explosion occur under internal forces only. External force is zero.

47. Assertion : NOT gate is also called invertor circuit.
Reason : NOT gate inverts the input order.

48. Assertion: The apparent weight of a body in an elevator moving downward with some acceleration is less than the actual weight of a body.
Reason: The part of the weight is spent in producing downward acceleration, when body is in elevator.

49. Assertion : Fragments produced in the fission of ${}^{235}_{92}U$ are not radioactive.
Reason : The fragmented elements have nearly the same number of protons and neutrons.

50. Assertion : The sky waves are not used in the transmission of television signals.
Reason : Sky waves are mechanical waves.

51. Assertion : The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down.
Reason : In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

52. Assertion : The susceptibility of diamagnetic materials does not depend upon temperature.
Reason : Every atom of a diamagnetic material is not a complete magnet in itself.

53. Assertion : Energy of K_α photon is approximated as $E(K_\alpha) = 13.6 \times \frac{3}{4}(Z-1)^2$
Reason : An electron of L-shell is partially screened by a electron of K-shell and so effective nuclear charge is $(Z - 1)$ units.

54. Assertion : In an elastic collision of two billiard balls, the total kinetic energy is conserved during the short time of oscillation of the balls (*i.e.*, when they are in contact).
Reason : Energy spent against friction does not follow the law of conservation of energy.

55. Assertion : It is not possible to have interference between the waves produced by two violins.
Reason : For interference of two waves the phase difference between the waves must remains constant.

56. Assertion : If the angles of the base of the prism are equal, then in the position of minimum deviation, the refracted ray will pass parallel to the base of prism.
Reason : In the case of minimum deviation, the angle of incidence is equal to the angle of emergence.

57. Assertion : A copper sheet is placed in a magnetic field. If we pull it out of the field or push it into the field, we experience an opposing force.
Reason : According to Lenz's law eddy current produced in sheet opposes the motion of the sheet.

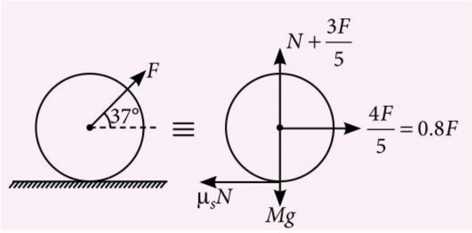
58. Assertion : Equal masses of helium and oxygen gases are given equal quantities of heat. There will be a greater rise in the temperature of helium as compared to that of oxygen.
Reason : The molecular weight of oxygen is more than the molecular weight of helium.

59. Assertion : If objective and eye lenses of a microscope are interchanged then it can work as telescope.
Reason : The objective lens of telescope has small focal length.

60. Assertion: For practical purposes, the earth is used as a reference at zero potential in electrical circuits.
Reason : The electrical potential of a sphere of radius R with charge Q uniformly distributed on the surface is given by $\frac{Q}{4\pi\varepsilon_0 R}$.

SOLUTIONS

1. (a) : $N = Mg - \dfrac{3F}{5} = Mg - 0.6\,F$



For pure rolling, $a = R\alpha$

$$\frac{0.8F - \mu_s N}{M} = R\left[\frac{(\mu_s N)R}{\left(\frac{1}{2}MR^2\right)}\right] \qquad \left(\because \alpha = \frac{\tau}{I}\right)$$

$0.8F = 3\mu_s N = 3(0.4)\,(Mg - 0.6F)$

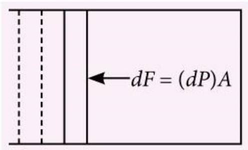
$F = 0.79\,Mg$

$\therefore$ Maximum value of $F = 0.79\,Mg$

2. (d) : At an equipotential surface, V = constant

Hence, potential energy of a point charge, qV, is also constant at every point of surface.

3. (c) : In adiabatic process,



$PV^{\gamma} = C$

$\ln P + \gamma \ln V = \ln C$

Taking differentials on both sides,

$$\frac{dP}{P} + \frac{\gamma dV}{V} = 0$$

or $\quad dP = \dfrac{-\gamma P}{V}dV \qquad$ ...(i)

where, dV = change in volume of the gas = Adx.

Substituting $dP = \dfrac{dF}{A}$, $P = P_0$, $V = V_0$ and $dV = Adx$ in the eqn. (i), we have

$$\left|\frac{dF}{A}\right| = \frac{\gamma P_0}{V_0}Adx$$

$$\Rightarrow \quad \left|\frac{dF}{dx}\right| = \frac{\gamma P_0 A^2}{V_0} \qquad \therefore \quad k_{eff} = \frac{\gamma P_0 A^2}{V_0}$$

$$\omega = \sqrt{\frac{k_{eff}}{m}} = \sqrt{\frac{\gamma P_0 A^2}{mV_0}}$$

4. (b)

5. (b) : Potential is zero on each capacitor. Then, net charge value $(Q_1 + Q_2)$ must be zero, *i.e.* magnitude of total charge must be zero.

Now, $Q_1 = C_1V_1$, $Q_2 = C_2V_2$

$\Rightarrow \quad Q_1 = 120C_1$ and $Q_2 = 200C_2$

As $\quad |Q_1| = |Q_2|$

$\therefore \quad 120C_1 = 200C_2 \quad \Rightarrow \quad 3C_1 = 5C_2$

6. (d) : The increase in length of the rod, due to rise in temperature in the absence of walls is $\Delta L = L\alpha\Delta\theta$

$\therefore \quad \Delta L = (1000)\,(10^{-4})\,(20) = 2$ mm

But the rod can expand upto 1001 mm only.

$\therefore$ Compression, $l = 1$ mm

So, stress developed $= Y\,\dfrac{l}{L} = 10^{11}\left(\dfrac{1}{1000}\right) = 10^8\,\text{Pa}$

7. (b) : At maximum height velocity $v = 0$

We know that $v = u + at$, hence

$0 = u - gT \;\Rightarrow\; u = gT$

When $v = \dfrac{u}{2}$, then

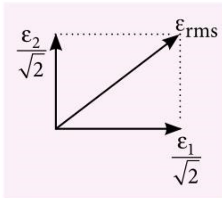
$$\frac{u}{2} = u - gt \Rightarrow gt = \frac{u}{2} = \frac{gT}{2} \Rightarrow t = \frac{T}{2}$$

Hence, at $t = \dfrac{T}{2}$, it acquires velocity $\dfrac{u}{2}$

8. (d) : Given, $\varepsilon = \varepsilon_1 \sin \omega t + \varepsilon_2 \cos \omega t$

rms value of alternating voltage, *i.e.*

$\varepsilon_{1\,\text{rms}} = \dfrac{\varepsilon_1}{\sqrt{2}}$ and



similarly $\varepsilon_{2\,\text{rms}} = \dfrac{\varepsilon_2}{\sqrt{2}}$

Using phasor diagram,

Net resultant root mean square of voltage is given by

$$\varepsilon_{\text{rms}} = \sqrt{\frac{\varepsilon_1^2 + \varepsilon_2^2}{2}}$$

9. (a) : Net force on M due to M and M, $2M$ and $2M$, $4M$ and $4M$, $5M$ and $5M$ and $7M$ and $7M$ is zero. The force due to $3M$ is

$$F = G\frac{M3M}{d^2} = \frac{3GM^2}{d^2} \text{ along } x\text{-axis}$$

10. (d) : Molar specific heat for a gas, $C = \dfrac{1}{n}\cdot\dfrac{dQ}{dT}$

It is possible to obtain any set to values for ΔQ and ΔT by proper selection of process.

As, $\Delta Q = 0$ is adiabtic process

$\therefore \quad C = 0$

and $\Delta T = 0$ is isothermal process

$\therefore \quad C = \infty$

11. (b) : The boat follows the shortest path. It is perpendicular to the bank of river.

BRAIN MAP CLASS XI

FLUID IN MOTION

FLUID IN MOTION

Flow of Fluid

- **Streamline flow :** The flow in which path taken by a fluid particle under a steady flow is a streamline in direction of the fluid velocity at that point.
- **Laminar flow :** The liquid is flowing with a steady flow and moves in the form of layers of different velocities and do not mix with each other, is called laminar flow.
- **Turbulent flow :** The flow in which velocity is greater than its critical velocity and the motion of particles becomes irregular is called turbulent flow.
- **Critical velocity :** The velocity of liquid flow upto which the flow is streamlined and above which it becomes turbulent is called critical velocity.
- In compressible flow, the density of fluid varies from point to point, whereas in incompressible flow, the density of the fluid remains constant throughout. Liquids are generally incompressible while gases are compressible.
- Rotational flow is the flow in which the fluid particles while flowing along path-lines also rotate about their own axis. In irrotational flow, particles do not rotate about their axis.

Reynold's Number

- Reynold's number $= \dfrac{\text{Inertial force per unit area}}{\text{Viscous force per unit area}}$

  or $N_R = \dfrac{v\rho d}{\eta}$

  Where v = velocity of liquid, ρ = density of liquid, d = diameter of tube, η = coefficient of viscosity of liquid.
  - On the basis of Reynold's number, we have,

  $0 < N_R < 2000 \rightarrow$ streamline flow.
  $2000 < N_R < 3000 \rightarrow$ streamline to turbulent flow.
  $3000 < N_R \rightarrow$ purely turbulent flow.

Equation of Continuity

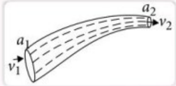
- According to conservation of mass, mass of liquid entering per second at wider end = mass of liquid leaving per second at narrower end

  $a_1 v_1 \rho_1 = a_2 v_2 \rho_2$

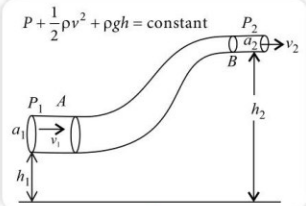
  $a_1 v_1 = a_2 v_2$

  (If liquid is incompressible, $\rho_1 = \rho_2 = \rho$)

  or av = constant



Bernoulli's Principle

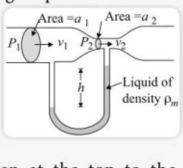


- It states that for a steady flow of an incompressible and non-viscous liquid the sum of the pressure (P), kinetic energy per unit volume (K) and potential energy per unit volume (U) remains constant throughout the flow.

- **Venturi-meter :** It is a device to measure the speed of flow of incompressible fluid.
  - Volume of the fluid flowing out per second

  $Q = a_1 v_1 = a_1 a_2 \sqrt{\dfrac{2h\rho_m g}{\rho(a_1^2 - a_2^2)}}$

  - $v_1 = \sqrt{\dfrac{2h\rho_m g}{\rho} \times \dfrac{a_2^2}{a_1^2 - a_2^2}}$

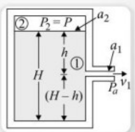


- **Torricelli's law :**
  - If the container is open at the top to the atmosphere then speed of efflux $v_1 = \sqrt{2gh}$.
  - Horizontal range, $R = v_1 \times t$

  $= \sqrt{2gh} \times \sqrt{\dfrac{2(H-h)}{g}} = 2\sqrt{h(H-h)}$

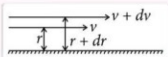
  R will be maximum if $h = \dfrac{H}{2}$, i.e., $R_{max} = H$
  - In general as shown in figure, speed of outflow,

  $v_1 = \sqrt{2gh + \dfrac{2(P - P_a)}{\rho}}$



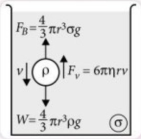
Viscosity

- The property of fluid due to which it opposes the relative motion between its different layers in a steady flow is called viscosity.

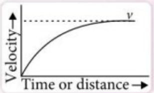


  - Tangential force between the layers, $F = -\eta A(dv/dr)$, where η = a constant called coefficient of viscosity.
  - SI unit of η is = N s m^{-2} or Poiseuille (Pl), Dimensions of $[\eta] = [ML^{-1}T^{-1}]$
- **Stokes' law :** The viscous drag opposing the motion is $F_v = 6\pi\eta r v$
  - Terminal velocity : $v = (2/9)[r^2(\rho - \sigma)g/\eta]$

  where ρ = density of sphere, σ = density of fluid medium, r = radius of sphere.



- The variation of velocity with time (or distance)



Poiseuille's Formula

- The rate of volume of fluid coming out of a narrow tube is

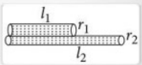
  $\dfrac{V}{t} = \dfrac{\pi P r^4}{8\eta l}$

  where P = pressure difference, l = length of tube, r = radius of cross-section of the tube.
  - Liquid resistance, $R = \dfrac{8\eta l}{\pi r^4}$
  - Series combination of tubes ($V_1 = V_2$)

  $\dfrac{V}{t} = \dfrac{P}{\left[\dfrac{8\eta l_1}{\pi r_1^4} + \dfrac{8\eta l_2}{\pi r_2^4}\right]}$

  Here, $P = P_1 + P_2$

  P_1 and P_2 are the pressure difference across the first and second tubes.
  - Parallel combination of tubes ($P_1 = P_2$)



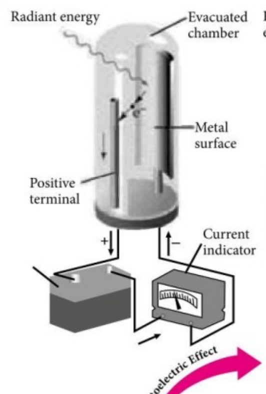
  Here, $V = V_1 + V_2$

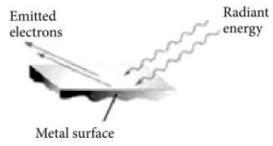
  $\dfrac{V}{t} = P\left[\dfrac{\pi r_1^4}{8\eta l_1} + \dfrac{\pi r_2^4}{8\eta l_2}\right]$

QUANTUM THEORY OF LIGHT

BRAIN MAP CLASS XII

PARTICLE NATURE OF RADIATION



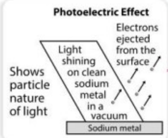


Photoelectric Cell

- An electrical device which converts light energy into electrical energy, is called as photocell or photoelectric cell.
- It works on the principle of photoelectric emission of electrons.

Application of Photoelectric Effect

Photoelectric Effect



- The phenomenon of emission of electrons from a metal surface when an electromagnetic wave of suitable frequency is incident on it is called photoelectric effect.

Basic Quantum Theory of Light

- According to Planck, the energy of a photon, $E \propto \upsilon$;

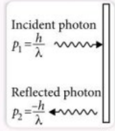
  $E = h\upsilon = \dfrac{hc}{\lambda} = \dfrac{1240}{\lambda(\text{in nm})}$ eV
- Momentum of photon, $p = \dfrac{E}{c} = \dfrac{h\upsilon}{c} = \dfrac{h}{\lambda}$
- If source is 100% efficient, then the number of photons emitted per second by the source can be given by

  $n = \dfrac{\text{Power of source}}{\text{Energy of photon}} = \dfrac{P}{E} = \dfrac{P}{h\upsilon} = \dfrac{P\lambda}{hc}$
- The energy crossing per unit area per unit time perpendicular to the direction of propagation is called the intensity of a wave.

  $I = E/At = P/A$
- Force exerted on perfectly reflecting surface

  $F = \dfrac{\Delta p}{t} = \dfrac{2Nh}{t\lambda} = n\left(\dfrac{2h}{\lambda}\right) = \dfrac{2P}{c}$

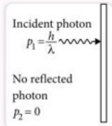
  Pressure $= \dfrac{F}{A} = \dfrac{2P}{cA} = \dfrac{2I}{c}$



- Force exerted on perfectly absorbing surface

  $F = \dfrac{\Delta p}{t} = \dfrac{Nh}{t\lambda} = n\left(\dfrac{h}{\lambda}\right) = \dfrac{P}{c}$

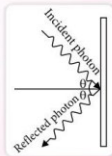
  Pressure $= \dfrac{F}{A} = \dfrac{P}{cA} = \dfrac{I}{c}$



- When a beam of light is incident at an angle θ on perfectly reflector surface then force exerted on the surface,

  $F = \dfrac{2P}{c}\cos\theta = \dfrac{2IA\cos\theta}{c}$

  Pressure $= \dfrac{2I\cos\theta}{c}$

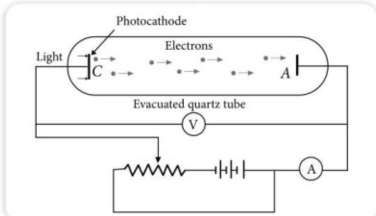


Photoelectric Equation

- $E = K_{max} + \phi_0$

  where ϕ_0 = work function of metal,
  E = energy of incident light,
  K_{max} = maximum kinetic energy of electrons
- $\dfrac{1}{2}mv_{max}^2 = h(\upsilon - \upsilon_0) = hc\left(\dfrac{1}{\lambda} - \dfrac{1}{\lambda_0}\right)$

  where, $\lambda_0 = \dfrac{hc}{\phi_0}$ = threshold wavelength



Conclusions of Experimental Study of Photoelectric Effect

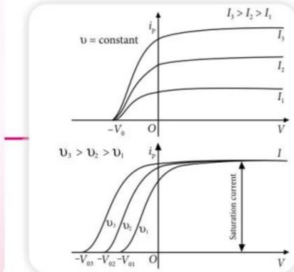
- Photo-current is directly proportional to the intensity of incident light, i.e., $i_p \propto I$.

  (At constant frequency υ and potential V)
- At constant frequency and intensity, the minimum negative potential at which the photocurrent becomes zero is called stopping potential (V_0).
- At stopping potential V_0, $K_{max} = eV_0$
- For a given frequency of the incident radiation, the stopping potential is independent of its intensity.
- The stopping potential varies linearly with the frequency of incident radiation but saturation current value remains constant for a fixed intensity of incident radiation.

- Quantum efficiency $= \dfrac{n_e}{n_{ph}}$

  n_e = number of electron emitted per second

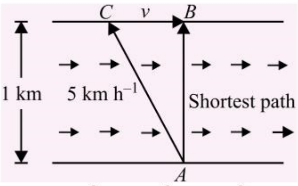
  n_{ph} = total number of photon incident per second



$\therefore$ Velocity of boat

$= \dfrac{\text{Distance}}{\text{Time}} = \dfrac{1\text{ km}}{15\text{ min}}$

$= \dfrac{1\times 60\text{ km}}{15\text{ h}} = 4\text{ km h}^{-1}$

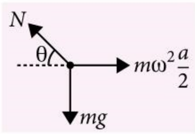


In the right angled triangle ABC, $AC^2 = AB^2 + CB^2$

$(5)^2 = (4)^2 + (CB)^2$ or $(CB)^2 = 9$

$\therefore$ $CB = 3\text{ km h}^{-1}$ = velocity of river

12. (b) : As $\cos\theta = \dfrac{a}{2a} \Rightarrow \theta = 60°$



$\therefore$ $N\sin 60° = mg$

$N\cos 60° = m\dfrac{\omega^2 a}{2}$

$\therefore$ $\tan 60° = \dfrac{2g}{\omega^2 a} \Rightarrow \omega^2 = \dfrac{2g}{a\sqrt{3}}$

13. (a) : As, rms value of current,

$I_{rms} = V_{rms}/Z$

So, net impedance across LCR circuit,

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(100)^2 + (\omega L - X_C)^2}$$

$$= \sqrt{(100)^2 + \left[\left(100\times\pi\times\frac{1}{\pi}\right) - (X_C)\right]^2}$$

$$\left(\frac{220}{2.2}\right)^2 = (100)^2 + \left((100) - (X_C)\right)^2 \Rightarrow X_C = 100\ \Omega$$

As, $\tan\theta = \dfrac{X_C}{R} = \dfrac{100}{100} = 1$

$\Rightarrow \theta = \tan^{-1}(1)$ or $\theta = 45°$

Power factor, $\cos\theta = \dfrac{1}{\sqrt{2}}$

14. (d) : Let V be the volume of the object.

$\therefore$ $V(\rho - \rho_1)g = m_1 g$ ...(i)

and $V(\rho - \rho_2)g = m_2 g$ ...(ii)

Divide (i) by (ii), we get

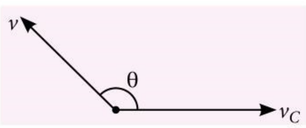
$$\frac{\rho - \rho_1}{\rho - \rho_2} = \frac{m_1}{m_2}$$

or $m_2\rho - m_2\rho_1 = m_1\rho - m_1\rho_2$

or $\rho(m_1 - m_2) = m_1\rho_2 - m_2\rho_1$

or $\rho = \dfrac{m_1\rho_2 - m_2\rho_1}{m_1 - m_2}$

15. (a) : $v_C = 45\text{ km h}^{-1} = \dfrac{25}{2}\text{ m s}^{-1}$



For the resultant motion to be upwards.

$v\cos\theta + v_C = 0$

$\cos\theta = -\dfrac{v_C}{v} = -\dfrac{25/2}{25} = -\dfrac{1}{2} \Rightarrow \theta = 120°$

16. (d) : When conductor moves a distance dx (in direction of v) in time dt, the component of displacement dx moved perpendicular to field is $dx\sin\theta$. And hence, induced emf

$$\varepsilon = -Bl\frac{dx}{dt}\sin\theta = -Blv\sin\theta = -l(\vec{v}\times\vec{B})$$

or $\varepsilon = l(\vec{B}\times\vec{v})$

17. (d) : The terminal velocity of the spherical body of radius R, density ρ falling through a liquid of density σ is given by

$$v_T = \frac{2}{9}\frac{R^2(\rho - \sigma)g}{\eta}$$

where η is the coefficient of viscosity of the liquid.

$\therefore$ $v_{T_1} = \dfrac{2R_1^2(\rho_1 - \sigma)g}{9\eta}$ and $v_{T_2} = \dfrac{2R_2^2(\rho_2 - \sigma)g}{9\eta}$

According to the given problem, $v_{T_1} = v_{T_2}$

$\therefore$ $R_1^2(\rho_1 - \sigma) = R_2^2(\rho_2 - \sigma)$ or $\dfrac{R_1^2}{R_2^2} = \dfrac{\rho_2 - \sigma}{\rho_1 - \sigma}$

Substituting the given values, we get

$$\frac{R_1^2}{R_2^2} = \frac{(11\times 10^3 - 2\times 10^3)}{(8\times 10^3 - 2\times 10^3)} = \frac{9}{6} = \frac{3}{2} \text{ or } \frac{R_1}{R_2} = \sqrt{\frac{3}{2}}$$

18. (a) : $U = bx^2 - ax \Rightarrow \dfrac{dU}{dx} = 2bx - a$

$F = \dfrac{-dU}{dx} = a - 2bx$

When $F = 0$, $x = \dfrac{a}{2b}$

Now, $k = \left|\dfrac{dF}{dx}\right|_{x=\frac{a}{2b}} = 2b$

$\therefore$ $\omega = \sqrt{\dfrac{k}{m}} \Rightarrow \upsilon = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}} = \dfrac{1}{2\pi}\sqrt{\dfrac{2b}{m}}$

19. (a) : As the trains are moving in the same direction. So the initial relative speed $(v_1 - v_2)$ and by applying retardation final relative speed becomes zero.

From $v = u - at = 0 \Rightarrow 0 = (v_1 - v_2) - at \Rightarrow t = \dfrac{v_1 - v_2}{a}$

20. (b)

21. (d) : For a faulty thermometer, if reading is y whereas correct reading is x then,

$$\frac{x - (\text{LFP})_{\text{correct scale}}}{(\text{UFP} - \text{LFP})_{\text{correct scale}}} = \frac{y - (\text{LFP})_{\text{incorrect scale}}}{(\text{UFP-LFP})_{\text{incorrect scale}}}$$

That means we can view them as two different scales.

So, $\frac{60-(-10)}{T-(-10)}=\frac{50-0}{100-0} \Rightarrow T = 130°C$

22. (d) : When a lift accelerates upwards with acceleration a, the apparent weight will be

$W_{app} = m(g + a) = 60\ (10 + 2) = 720$ N

23. (b) : Energy density $\left(\frac{dU}{dV}\right)=\frac{B^2}{2\mu_0}$

i.e., $U=\int_0^R \frac{B^2}{2\mu_0}dV$

Magnetic field in a straight wire, *i.e.*, $B=\frac{\mu_0 Ir}{2\pi R^2}$

$dV = 2\pi r\, dr$

where, r is a radius of circular cross-section of wire.

$$U=\int_0^R\left(\frac{\mu_0^2 I^2 r^2}{4\pi^2 R^4}\right)\frac{2\pi r dr}{2\mu_0}=\int_0^R\frac{\mu_0 I^2}{4\pi}\times\frac{1}{R^4}\times r^3 dr$$

$$=\left(\frac{\mu_0 I^2}{4\pi R^4}\right)\times\left[\frac{r^4}{4}\right]_0^R=\frac{\mu_0}{4\pi}\times\frac{I^2}{R^4}\times\left[\frac{R^4}{4}-0\right]$$

$$U=\frac{\mu_0 I^2}{16\pi}$$

24. (a) : States 1 and 2 are at the same temperature. Also states 4 and 5 are at same temperature.

As v_p is more at higher temperature and same at all states at equal temperature.

$\therefore \quad v_{p\text{ at }3} > v_{p\text{ at }1} = v_{p\text{ at }2} > v_{p\text{ at }4} = v_{p\text{ at }5}$

25. (b) : $\mu_2 = \frac{\mu_1}{4}$ (given), $T_1 = T_2$

$\therefore \quad \mu_2 v_2^2 = \mu_1 v_1^2 \Rightarrow v_2=\sqrt{\frac{\mu_1}{\mu_2}}v_1=\sqrt{4}v_1=2v_1$

or $\quad v_2 = 20$ cm s^{-1}

26. (c) : Here, temperature of source, $T_1 = 227°C = 500$ K

Temperature of sink, $T_2 = 127°C = 400$ K

Heat absorbed from the source, $Q_1 = 6 \times 10^4$ cal

Heat rejected to the sink Q_2 = ?

As $\frac{Q_1}{Q_2}=\frac{T_1}{T_2}$

Substituting the given values, we get

$$\frac{6\times10^4\text{ cal}}{Q_2}=\frac{500\text{ K}}{400\text{ K}}$$

or $\quad Q_2=\frac{4}{5}\times6\times10^4\text{ cal}=4.8\times10^4\text{ cal}$

$\therefore \quad W = Q_1 - Q_2 = 6\times10^4\text{ cal}-4.8\times10^4\text{ cal}=1.2\times10^4\text{ cal}$

27. (b) : Steady state temperature of resistor depends not only on the power but also on surface area, emissivity, etc. Bulb is of less power but acquires more temperature (~ 1600°C).

28. (c) : Initially, both A and B are at same temperature but B loses heat much rapidly than A. So, fall of temperature of B is more than that of A in same time. Hence, $e_A > e_B$. As good emitters are also good absorbers so, $a_A > a_B$.

29. (b) : $(I_{AA'})_{rod}=\frac{ML^2}{12}+M\left(\frac{L}{2}\right)^2=\frac{ML^2}{3}$

$(I_{AA'})_{sphere}=\frac{2}{5}mr^2+mL^2$

$(I_{AA'})_{system}=\frac{ML^2}{3}+\frac{2}{5}mr^2+mL^2=L^2\left(m+\frac{M}{3}\right)+\frac{2}{5}mr^2$

30. (d) : The speed of spaceship in a circular orbit close to the earth's suface is given by $v_o=\sqrt{gR}$

We know that, $v_e=\sqrt{2gR}$

Additional velocity required to escape $= v_e - v_o$

$= (\sqrt{2}-1)\sqrt{gR}$

31. (b) : As power, $P=\frac{dU}{dt}=\frac{\text{Energy emitted}}{\text{Time}}$

Hence, $E = P\Delta t$

Also, E = number of photons × energy of 1 photon

So, number of photons

$N=\frac{E}{h\upsilon}=\frac{P\Delta t}{h\upsilon}$

$\therefore$ Number of photons emitted by source per unit time

$n=\frac{N}{\Delta t}=\frac{P}{h\upsilon}$

As $\upsilon_b > \upsilon_r$ and $\frac{n_r}{n_b}=\frac{\upsilon_b}{\upsilon_r}>1$

$\Rightarrow n_r > n_b$

32. (d) : Mean free path, $\lambda=\frac{1}{\sqrt{2}\pi d^2 n}$

where n is the number density and d is the diameter of the molecule.

As $PV = Nk_BT \quad \therefore \quad n=\frac{N}{V}=\frac{P}{k_BT}$

Thus, $\lambda=\frac{1}{\sqrt{2}\pi d^2\left(\frac{P}{k_BT}\right)}=\frac{k_BT}{\sqrt{2}\pi d^2 P}$ or $d^2=\frac{k_BT}{\sqrt{2}\pi P\lambda}$

Here, $\quad k_B = 1.4 \times 10^{-23}$ J K^{-1}, $\lambda = 2.1 \times 10^{-7}$ m,

At STP, $T = 0°C = 273$ K, $P = 1$ atm $= 1.01 \times 10^5$ N m^{-2}

$$\therefore \quad d^2=\frac{1.4\times10^{-23}\times273}{\sqrt{2}\times3.14\times1.01\times10^5\times2.1\times10^{-7}}$$

$= 4.06 \times 10^{-20}$ m^2 or $d = 2.01 \times 10^{-10}$ m ≈ 2.01 Å

33. (a)

34. (a) : $\vec{F}\propto(\vec{v}\times\vec{B})=\hat{k}(aD-dA)$

35. (d) : Given : $\alpha = 0.96$

$$\therefore \quad \beta = \frac{\alpha}{1-\alpha} = \frac{0.96}{1-0.96} = 24$$

Collector current,

$$I_C = \frac{\text{Voltage drop across } R_C}{\text{Resistance } R_C} = \frac{0.5}{500} = 1\times10^{-3}\,\text{A} = 1\text{ mA}$$

Also $\quad \beta = \frac{I_C}{I_B} \quad \therefore \quad I_B = \frac{I_C}{\beta} = \frac{1\text{ mA}}{24} = \frac{1}{24}\text{ mA}$

36. (a) : Here, radius of the wheel, $R = 0.7$ m

Frequency of rotation of the wheel,

$$\upsilon = 120\text{ rpm} = \frac{120}{60}\text{ rps} = 2\text{ rps}$$

Magnetic field, $B = H_E = 0.8\text{ G} = 0.8\times10^{-4}\text{ T}$

Induced emf across the ends of a spoke,

$$\varepsilon = B\pi R^2\upsilon = 0.8\times10^{-4}\times3.14\times(0.7)^2\times2 = 2.46\times10^{-4}\text{ V}$$

As all the 30 spokes are connected in parallel, therefore emf induced across each spoke is same. Thus, the induced emf between the axle and the rim of the wheel is same as across any spoke *i.e.* 2.46×10^{-4} V.

The number of spokes is immaterial.

37. (c)

38. (c) : Relative density of stone,

$$K = \frac{\text{Density of stone}}{\text{Density of water}} = \frac{\rho_{\text{stone}}}{\rho_{\text{water}}} \qquad \text{...(i)}$$

Let V be volume of the stone.

Weight of the stone, $W = V\rho_{\text{stone}}\,g$

Buoyant force (upthrust) on the stone due to water,

$B = V\rho_{\text{water}}\,g$

Net downward force on the stone,

$$F = W - B = V\rho_{\text{stone}}\,g - V\rho_{\text{water}}\,g$$

$$= V\rho_{\text{stone}}\,g\left(1-\frac{\rho_{\text{water}}}{\rho_{\text{stone}}}\right)$$

$$= V\rho_{\text{stone}}\,g\left(1-\frac{1}{K}\right) \qquad \text{(Using (i))}$$

$$= mg\left(1-\frac{1}{K}\right) \qquad (\because \text{ Mass of stone, } m = V\rho_{\text{stone}})$$

Acceleration of the stone,

$$a = \frac{F}{m} = \frac{mg\left(1-\frac{1}{K}\right)}{m} = g\left(1-\frac{1}{K}\right)$$

39. (d) : Let v_i be initial speed of α-particle and v_α and v_p are final speeds of α-particle and proton.

Then, $4m_p \,.\, v_i = 4m_p v_\alpha + m_p v_p \qquad [\because\ m_\alpha \approx 4m_p]$

Collision being elastic, $v_i - 0 = v_p - v_\alpha$

Eliminating v_i from there, we get

$$4v_p - 4v_\alpha = 4v_\alpha + v_p \text{ or } v_\alpha = \frac{3}{8}v_p$$

Now, de-Broglie wavelength of proton and α-particle are $\lambda_p = \frac{h}{m_p v_p}$ and $\lambda_\alpha = \frac{h}{m_\alpha v_\alpha}$

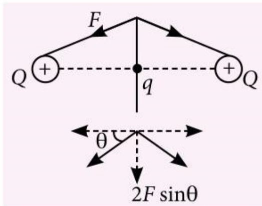
$$\therefore \quad \frac{\lambda_\alpha}{\lambda_p} = \frac{h}{m_\alpha v_\alpha}\times\frac{m_p v_p}{h} = \left(\frac{m_p}{m_\alpha}\right)\cdot\left(\frac{v_p}{v_\alpha}\right) = \frac{1}{4}\times\frac{8}{3} = \frac{2}{3}$$

40. (a) : Restoring force $= 2F\sin\theta$

$$= \frac{2KQq}{(a^2+x^2)}\cdot\frac{x}{\sqrt{a^2+x^2}}$$

$$= \frac{2KQq}{a^3}\cdot x$$

($\because\ x$ is small as compare to a)



$\therefore \quad$ Acceleration, $a = -\omega^2 x = \frac{F}{m}$

and frequency $= \frac{1}{2\pi}\sqrt{\frac{Qq}{2\pi\varepsilon_0 ma^3}}$

41. (d) : Assertion is incorrect as in a p-n junction or in a n-type semiconductor phosphorus atoms are not isolated and there are enough free charge carriers in a semiconductor at room temperature.

42. (b) : Loss of energy is maximum when collision is inelastic.

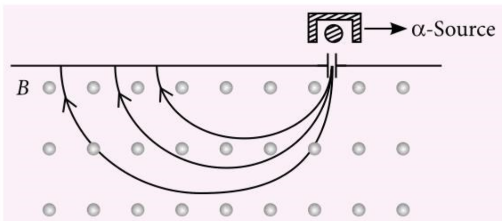
Maximum energy loss $= \frac{1}{2}\frac{mM}{(M+m)}u^2$

43. (b)

44. (b) : Radius of path of α-particle in region of a uniform perpendicular magnetic field is

$$r = \frac{\sqrt{2\,Km}}{2eB}$$

As α-particles have only discreate and quantised energy values (K), so, they follow circular path of fixed radii.



45. (b) : As density of water is twice the density of ball,

$\therefore \quad$ upthrust = weight of water displaced

$\qquad\qquad$ = 2 × weight of ball

$\therefore$ Net upward force on the ball = $mg - 2mg = -mg$ therefore, inside water $a = -g$. Hence ball will stop at the same depth as height from which it started.

46. (a) : Explosion is due to internal forces. As no external force is involved, the vertical downward motion of centre of mass is not affected.

47. (a) : A NOT gate puts the input condition in the opposite order, means for high input it give low output and for low input it gives high output. For this reason NOT gate is known as invertor circuit.

48. (b) : The apparent weight of a body in an elevator moving with downward acceleration $a = m(g - a)$.

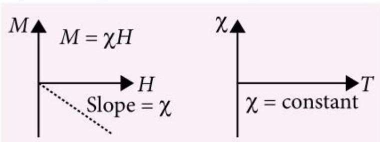
49. (d)

50. (c) : T.V. signals are of high frequencies (100 MHz to 200 MHz). They cannot be reflected to earth by ionosphere, whereas skywaves are reflected from ionosphere. Hence sky waves are not used for the transmission of T.V. signals. The waves which are reflected from ionosphere (frequency in range 2 MHz to 20 MHz) are called sky waves or ionospheric propagation.

51. (a) : As the stream falls down, its speed will increase and cross-section area will decrease, it will become narrow. Similarly as the stream will go up, speed will decrease and cross-section area will increase, it will become broader.

52. (c) : Diamagnetic substance are composed of atom which have no net magnetic moment (*i.e.*, all the orbital shells are filled and there are no unpaired electrons). When exposed to a field, a negative magnetization is produced and thus the susceptibility is negative.

Behaviour of diamagnetic material is that the susceptibility is temperature independent.



53. (a) : Due to partial screening,

$Z_{eff} = (Z - 1)$ and so for

$n = 2 \rightarrow n = 1$ transition,

$$E_{K_\alpha} = \frac{-ke^2}{2a_0}\frac{(Z-1)^2}{Z^2} - \left(\frac{-ke^2}{2a_0}\frac{(Z-1)^2}{1^2}\right)$$

$$= \frac{ke^2}{2a_0} \times \frac{3}{4}(Z-1)^2 = 13.6 \times \frac{3}{4}(Z-1)^2$$

54. (d) : In an elastic collision, linear momentum and kinetic energy, both, are always conserved. Energy transformation occurs. Due to friction, mechanical energy may be converted into heat energy.

55. (a) : Since the initial phase difference between the two waves coming from different violins changes, therefore, the waves produced by two different violins does not interfere because two waves interfere only when the phase difference between them remain constant throughout.

56. (a) : If μ is the refractive index of glass with respect to air, then according to Snell's law for the refraction of light,

$$\mu = \frac{\sin i}{\sin r} \text{ (At the point of incidence)}$$

and, $$\mu = \frac{\sin e}{\sin r'} \text{ (At the point of emergence)}$$

Because, for minimum deviation $i = e$, hence $r = r'$.

57. (a) : When we pull a copper plate out of the magnetic field or push it into the magnetic field, magnetic flux linked with the plate changes. As a result of this eddy currents are produced in the plate which oppose its motion (according to Lenz's law).

58. (b) : Helium is a monatomic gas, while oxygen is diatomic. Therefore, the heat given to helium will be totally used up in increasing the translational kinetic energy of its molecules; whereas the heat given to oxygen will be used up in increasing the translational kinetic energy of the molecule and also in increasing the kinetic energy of rotation and vibration. Hence there will be a greater rise in the temperature of helium.

59. (d) **60. (b)**

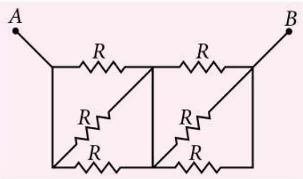
FULL LENGTH PRACTICE PAPER

BITSAT

Exam date : 16^{th} to 31^{st} May 2018

SECTION-I (PHYSICS)

1. In the circuit as shown in the figure, the value of each resistance is R, then equivalent resistance between points A and B is



(a) $\frac{5}{7}R$ (b) $\frac{2}{3}R$ (c) $\frac{1}{2}R$ (d) R

2. The maximum heights of a projectile for projection angles θ and $(90 - \theta)$ are H_1 and H_2. R is the range in each case. The relation between R, H_1 and H_2 can be expressed as

(a) $R = \sqrt{H_1 H_2}$ (b) $R^2 = H_1^2 + H_2^2$
(c) $R = H_1 + H_2$ (d) $R = 4\sqrt{H_1 H_2}$

3. Two spheres of radii R_1 and R_2 have densities ρ_1 and ρ_2 and specific heats C_1 and C_2 respectively. If they are heated to the same temperature, the ratio of their rates of cooling will be

(a) $\frac{R_2 \rho_1 C_1}{R_1 \rho_2 C_2}$ (b) $\frac{R_1 \rho_1 C_1}{R_2 \rho_2 C_2}$
(c) $\frac{R_1 \rho_2 C_2}{R_2 \rho_1 C_1}$ (d) $\frac{R_2 \rho_2 C_2}{R_1 \rho_1 C_1}$

4. An electron orbiting around a nucleus has angular momentum L. The magnetic field produced by the electron at the centre of the orbit can be expressed as

(a) $B = \left(\frac{\mu_0 e}{8\pi m r^3}\right)L$ (b) $B = \left(\frac{\mu_0 e}{4\pi m r^3}\right)L$
(c) $B = \left(\frac{\mu_0 e}{\pi m r^3}\right)L$ (d) $B = \left(\frac{e}{4\pi\varepsilon_0 m r^3}\right)L$

5. If the radius of earth shrinks by 1.5% (mass remaining same), then the value of acceleration due to gravity changes by

(a) 1% (b) 2% (c) 3% (d) 4%

6. In Young's double slit experiment, the fringe width is β. If the entire arrangement is placed in a liquid of refractive index μ, the fringe width becomes

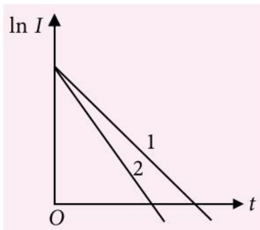
(a) $\mu\beta$ (b) $\frac{\beta}{\mu+1}$ (c) $\frac{\beta}{\mu-1}$ (d) $\frac{\beta}{\mu}$

7. Voltage of modulating wave of 5 V with 10 MHz frequency was superimposed on carrier wave of frequency 20 MHz and voltage 20 V then the modulation index is

(a) 0.25 (b) 1.25
(c) 2.43 (d) 64.0

8. A capacitor of capacitance C is charged to a potential difference V_0 and is then discharged through a resistance R. The discharge current gradually decreases, with a straight line 1 corresponding to this process, as shown in figure where time is along x-axis and the logarithm of the current on y-axis. Later on, one of the three parameters V_0, R or C, is changed (keeping the other two unchanged) in such a manner that the ln I versus t dependence is represented by the straight line 2.

Which option correctly represents the change?



(a) V_0 is decreased
(b) R is decreased
(c) R is increased
(d) C is decreased.

9. At 0 K, the quantity which is zero for a gas is

(a) Potential energy (b) Kinetic energy
(c) Internal energy (d) Vibrational energy

10. An isolated and charged spherical soap bubble has a radius r and the pressure inside is equal to

atmospheric pressure. If T is the surface tension of soap solution, then charge on drop is

(a) $2\sqrt{\dfrac{2rT}{\varepsilon_0}}$ (b) $8\pi r\sqrt{2rT\varepsilon_0}$

(c) $8\pi r\sqrt{rT\varepsilon_0}$ (d) $8\pi r\sqrt{\dfrac{2rT}{\varepsilon_0}}$

11. If the ratio of specific heat of a gas at constant pressure to that at constant volume is γ, the change in internal energy of a gas, when the volume changes from V to $2V$ at constant pressure P is

(a) $\dfrac{(V-1)}{PV}$ (b) $\dfrac{PV}{(\gamma-1)}$

(c) $\dfrac{P}{V(\gamma-1)}$ (d) $\dfrac{V}{P(\gamma-1)}$

12. According to zeroth law of thermodynamics, if the systems in contact are in thermal equilibrium,
(a) the temperature of two systems is zero
(b) one system provides heat to the other system
(c) one system absorbs heat from the other system
(d) no heat flows between them.

13. A transverse wave is described by the equation $y = y_0 \sin 2\pi\left(\upsilon t - \dfrac{x}{\lambda}\right)$. The maximum particle velocity is four times the wave velocity if

(a) $\lambda = \dfrac{\pi y_0}{4}$ (b) $\lambda = 2\pi y_0$

(c) $\lambda = \pi y_0$ (d) $\lambda = \dfrac{\pi y_0}{2}$

14. A and B are two identical spherical charged bodies which repel each other with force F, kept at a finite distance. A third uncharged sphere C of the same size is brought in contact with sphere B and removed. It is then kept at mid-point of A and B. Find the magnitude of force on C.
(a) $F/2$ (b) $F/8$ (c) F (d) zero

15. Two tuning forks A and B vibrating together produce 5 beats per second. Frequency of B is 512 Hz. It is seen that if one arm of A is filed, then the number of beats increase. Frequency of A will be
(a) 502 Hz (b) 507 Hz
(c) 522 Hz (d) 517 Hz

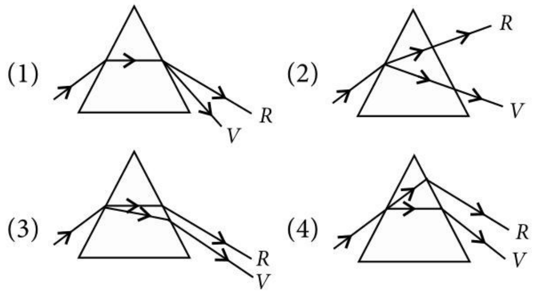
16. The kinetic energy of a particle moving along a circle of radius R is K.E. $= \beta x^2$ where x is the distance covered. The force acting on the particle is

(a) $2\beta x\,(R^2 - x^2)$ (b) $2\beta x\sqrt{1+\dfrac{x^2}{R^2}}$

(c) $2\beta x^2 R$ (d) $2\beta x R^2$

17. A uniform chain of length l is placed on a rough table with length l/n (where $n > 1$), hanging over the edge. If the chain just begins to slide off the table by itself from this position, the coefficient of friction between the chain and the table is
(a) $1/n$ (b) $1/(n - 1)$
(c) $1/(n + 1)$ (d) $(n - 1)\,(n + 1)$

18. Which of the following figure is a correct representation of deviation and dispersion of light by a prism ?



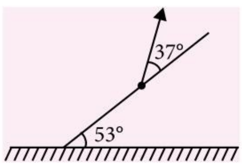
(a) 1 (b) 2 (c) 3 (d) 4

19. A photosensitive metallic surface has work function, $h\upsilon_o$. If photons of energy $2h\upsilon_0$ fall on this surface, the electron come out with a maximum velocity of 4×10^6 m s^{-1}. When the photon energy is increased to $5h\upsilon_0$, then maximum velocity of photo electron will be
(a) 2×10^7 m s^{-1} (b) 2×10^7 m s^{-1}
(c) 8×10^5 m s^{-1} (d) 8×10^6 m s^{-1}

20. The potential energy of a mass m is given by the following relation
$U = E_0$ for $0 \le x \le 1$
$= 0$ for $x > 1$
If λ_1 and λ_2 are the de-broglie wavelengths of the mass in the region $0 \le x \le 1$ and $x > 1$ respectively and the total energy be $2E_0$ then find the value of $\dfrac{\lambda_1}{\lambda_2}$?

(a) $\sqrt{2}$ (b) $\dfrac{1}{\sqrt{2}}$ (c) 2 (d) $\dfrac{1}{2}$

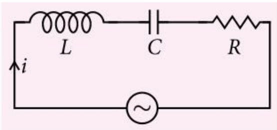
21. A particle is projected from the inclined plane at angle 37° with the inclined plane in upward direction with speed 10 m s^{-1}. The



angle of inclined plane with horizontal is 53°. Then the maximum height attained by the particle from the incline plane will be

(a) 3 m (b) 4 m (c) 5 m (d) zero

22. The following circuit is in the state of resonance. Which of the following statement is correct?



(a) Value of i depends upon the value of L, C and R.
(b) Maximum current flows in circuit.
(c) Minimum current flows in circuit.
(d) Power factor is 0.

23. A large number of water droplets, each of radius r, combine to have a drop of radius R. If the surface tension is T and mechanical equivalent of heat is J, the rise in heat energy per unit volume will be

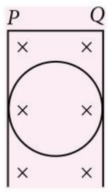
(a) $\frac{2T}{rJ}$ (b) $\frac{3T}{rJ}$

(c) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ (d) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

24. A cylinder with a fixed volume contains hydrogen gas H_2 at 25 K, then we add heat to the gas at constant rate until its temperature reaches 500 K. Does the temperature of the gas increases at a constant rate ?

(a) Yes.
(b) No, it is increasing rapidly at the end of the process.
(c) No, it is increasing rapidly at the beginning of the process.
(d) No, but its variable rate can't be described.

25. A vertical ring of radius r and resistance R falls vertically. It is in contact with two vertical rails which are joined at the top. The ring moves without friction and resistance. There is a horizontal uniform magnetic field of magnitude B perpendicular to the plane of the ring and the rails. When the speed of the ring is v, the current in the section PQ is



(a) zero (b) $\frac{2Brv}{R}$ (c) $\frac{4Brv}{R}$ (d) $\frac{8Brv}{R}$

26. A long straight wire carries a charge with linear density λ. A particle of mass m and a charge q is released at a distance r from the wire. The speed of the particle as it crosses a point at a distance $2r$ is

(a) $\sqrt{\frac{q\lambda \ln r}{\pi m \varepsilon_0}}$ (b) $\sqrt{\frac{q\lambda \ln 2}{\pi m \varepsilon_0}}$

(c) $\sqrt{\frac{q\lambda \ln 2}{2\pi m \varepsilon_0}}$ (d) $\sqrt{\frac{q\lambda \ln r}{2\pi m \varepsilon_0}}$

27. The bob of a simple pendulum of mass m and total energy E will have maximum linear momentum equal to

(a) $2mE$ (b) mE^2

(c) $\sqrt{2mE}$ (d) $\sqrt{\frac{2E}{m}}$

28. A tuning fork of length l, thickness t is made of material having Young's modulus Y and density ρ. Frequency υ of a tuning fork is given by
(Here k is a constant)

(a) $\frac{kt}{l}\sqrt{\frac{Y}{\rho}}$ (b) $\frac{kt^2}{l^2}\sqrt{\frac{Y}{\rho}}$

(c) $\frac{kt}{l^2}\sqrt{\frac{Y}{\rho}}$ (d) $\frac{kt^2}{l}\sqrt{\frac{Y}{\rho}}$

29. A particle of mass $m = 5$ units is moving with a uniform speed $v = 3\sqrt{2}$ units in the XOY plane along the line $y = x + 4$. The magnitude of the angular momentum of the particle about the origin is

(a) 60 units (b) $40\sqrt{2}$ units
(c) zero (d) 7.5 units

30. An electron is travelling along the x-direction. It encounters a magnetic field in the y-direction. Its subsequent motion will be

(a) straight line along the x-direction
(b) a circle in the xz plane
(c) a circle in the yz plane
(d) a circle in the xy plane.

31. A beam of light is converging towards a point I on a screen. A plane parallel plate of glass of thickness t (in the direction of the beam) and refractive index of μ is inserted in the path of the beam. The convergence point is shifted by

(a) $t\left(1-\frac{1}{\mu}\right)$ away (b) $t\left(1+\frac{1}{\mu}\right)$ away

(c) $t\left(1-\frac{1}{\mu}\right)$ nearer (d) $t\left(1+\frac{1}{\mu}\right)$ nearer

32. In a common emitter transistor the base current $I_B = 2\ \mu A$, $\alpha = 0.9$, then $I_C =$
(a) 18 μA (b) 20 μA
(c) 22 μA (d) 24 μA

33. The time dependence of a physical quantity p is given by $p = p_0\, e^{-\alpha t^2}$, where α and p_0 are constants and t is the time. The constant α
(a) is dimensionless
(b) has dimensions $[T^{-2}]$
(c) has dimensions $[T^2]$
(d) has dimensions of p

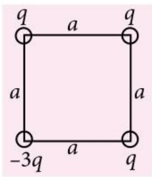
34. The moment of inertia of a solid cylinder of mass M and radius R about a line parallel to the axis of the cylinder out lying on the surface of the cylinder is
(a) $M(L^2 + R^2)$ (b) MR^2
(c) $M\left(\frac{L^2}{12}+\frac{R^2}{4}\right)$ (d) $\frac{3}{2}MR^2$

35. A whistle sends out 256 waves in a second. If the whistle approaches the observer with velocity $\frac{1}{3}$rd of the velocity of sound in air, the number of waves per second received by the observer will be
(a) 300 (b) 192
(c) 384 (d) 200

36. Two planets have the same average density and their radii are R_1 and R_2. If acceleration due to gravity on these planets be g_1 and g_2 respectively, then
(a) $\frac{g_1}{g_2} = \frac{R_1}{R_2}$ (b) $\frac{g_1}{g_2} = \frac{R_2}{R_1}$
(c) $\frac{g_1}{g_2} = \frac{R_1^2}{R_2^2}$ (d) $\frac{g_1}{g_2} = \frac{R_1^3}{R_2^3}$

37. 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture is (latent heat of fusion of ice is 80 cal g^{-1} and specific heat capacity of water 1 cal $g^{-1}\ {}^\circ C^{-1}$)
(a) 0°C (b) 40°C (c) 80°C (d) 25°C

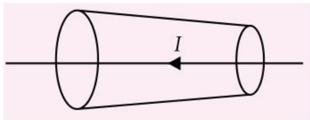
38. Electric dipole moment of combination shown in the figure is



(a) $qa + aq\sqrt{2} + qa$
(b) $2\sqrt{2}qa$
(c) $\sqrt{2}qa$
(d) $\left(\sqrt{2}+1\right)qa$.

39. A hydrogen atom and a Li^{++} ion are both in the second excited state. If l_H and l_{Li} are their respective electronic angular momenta, and E_H and E_{Li} their respective energies, then
(a) $l_H > l_{Li}$ and $|E_H| > |E_{Li}|$
(b) $l_H = l_{Li}$ and $|E_H| < |E_{Li}|$
(c) $l_H = l_{Li}$ and $|E_H| > |E_{Li}|$
(d) $l_H < l_{Li}$ and $|E_H| < |E_{Li}|$.

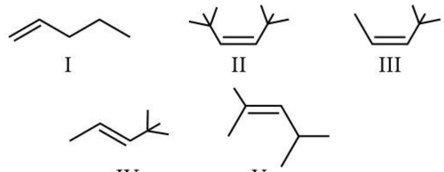
40. A constant current I is flowing along the length of a conductor of variable cross-section as shown in the figure. The quantity which does not depend upon the area of cross-section is



(a) electron density (b) current density
(c) drift velocity (d) electric field

SECTION-II (CHEMISTRY)

41. Choose the correct comparison of heat of hydrogenation for the following alkenes :



I II III IV V

(a) II < IV < III < V < I
(b) III < IV < I < V < II
(c) V < IV < III < I < II
(d) IV < V < I < III < II

42. Phenol and cyclohexanol can be chemically distinguished by all the given reagents except
(a) Br_2/H_2O
(b) anhydrous $ZnCl_2$/conc. HCl
(c) neutral $FeCl_3$
(d) metallic sodium.

43. If λ_0 is the threshold wavelength for photoelectric emission, λ is the wavelength of light falling on the surface of a metal and m is the mass of the electron, then the velocity of ejected electron is given by
(a) $\left[\frac{2h}{m}(\lambda_0 - \lambda)\right]^{1/2}$ (b) $\left[\frac{2hc}{m}(\lambda_0 - \lambda)\right]^{1/2}$
(c) $\left[\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda_0 \lambda}\right)\right]^{1/2}$ (d) $\left[\frac{2h}{m}\left(\frac{1}{\lambda_0} - \frac{1}{\lambda}\right)\right]^{1/2}$

44. The weight of 1 g-equivalent of V_2O_5 used in the reaction :

$Zn + V_2O_5 \longrightarrow ZnO + V$ is (At. wt. of V = A)

(a) $\frac{A}{5}$ (b) $\frac{A+80}{5}$

(c) $\frac{2A+80}{5}$ (d) $\frac{2A+80}{10}$

45. Which of the following is likely to be the e.m.f. of the cell (chloride based) shown below?

$Ag_{(s)}|AgCl(K_{sp})|\ Cl^-(x\ M)||AgCl(K_{sp})|Ag_{(s)}$

(a) $0.059 \log \frac{x}{\sqrt{K_{sp}}}$

(b) $0.059 \log [(x)(K_{sp})]$

(c) $0.059 \log \frac{\sqrt{K_{sp}}}{x}$

(d) Data is insufficient for calculation.

46. Which of the following values of stability constant K corresponds to the most unstable complex compound?

(a) 1.6×10^7 (b) 4.5×10^{14}

(c) 2.0×10^{27} (d) 5.0×10^{33}

47. Which of the following mixtures will give a buffer solution when dissolved in 500.00 mL of water?

(a) 0.200 mol of aniline and 0.200 mol of HCl

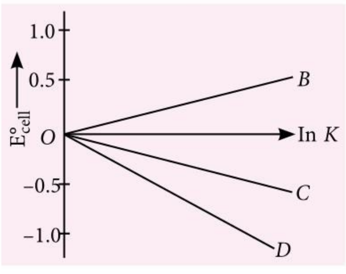
(b) 0.200 mol of aniline and 0.400 mol of NaOH

(c) 0.200 mol of NaCl and 0.100 mol of HCl

(d) 0.200 mol of aniline and 0.100 mol of HCl

48. Given : $\Delta G° = -nFE°_{cell}$ and $\Delta G° = -RT \ln K$

The value of n = 2 will be given by the slope of which line in the given figure?



(a) OD (b) OB

(c) OC (d) none of these

49. 0.553 g of boron-hydrogen compound created a pressure of 0.658 atm in a bulb of 407 mL at 373 K. If the compound has 85.7% boron, what will be the molecular formula of the compound?

(Given atomic mass of B = 10.8)

(a) B_2H_6 (b) B_3H_8 (c) B_5H_9 (d) B_6H_{14}

50. At what temperature will a 5% solution (weight/volume) of glucose develop an osmotic pressure of 7 atm?

(a) 33.94 °C (b) 54.76 °C

(c) 24.55 °C (d) 47.32 °C

51. Which of the following ions does not involve $p\pi\text{–}d\pi$ bonding?

(a) SO_3^{2-} (b) PO_4^{3-}

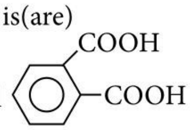
(c) NO_3^- (d) $XeOF_4$

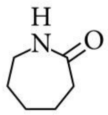
52. An ideal gas with pressure P, volume V and temperature T is expanded isothermally to a volume $2V$ and a final pressure is P_I. If the same gas is expanded adiabatically to a volume $2V$, and the final pressure is P_{II} and the ratio of specific heats for the gas is 1.67, then the ratio of P_{II}/P_I is

(a) $\frac{1}{(2)^{0.67}}$ (b) $(2)^{0.67}$

(c) $\left(-\frac{1}{2}\right)^{-0.67}$ (d) $\frac{1}{2^{-0.67}}$

53. The monomer(s) of dacron is(are)

(a) $HOCH_2\text{—}CH_2OH$ and 

(b) 

(c) $HOCH_2\text{—}CH_2OH$ and

(d) $F_2C{=}CF_2$

54. To avoid the precipitation of hydroxides of Ni^{2+}, Co^{2+}, Zn^{2+} and Mn^{2+} along with those of Fe^{3+}, Al^{3+} and Cr^{3+}, the third group solution should be

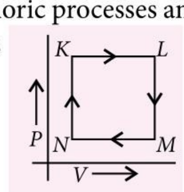
(a) heated with a few drops of conc. HNO_3

(b) treated with excess of NH_4Cl

(c) concentrated

(d) none of these.

55. A fixed mass of a gas is subjected to transformations of state from K to L to M to N and back to K as shown in the figure. The pair of isochoric processes among the transformations of state is



(a) K to L and L to M

(b) L to M and N to K

(c) L to M and M to N

(d) M to N and N to K

56. A nuclide of an alkaline earth metal undergoes radioactive decay by emission of α-particle in succession to give the stable nucleus. The group of the periodic table to which the resulting daughter element would belong is
(a) group 4 (b) group 6
(c) group 16 (d) group 14.

57. The rate of change of concentration of (A) for reaction: $A \longrightarrow B$ is given by $\frac{-d[A]}{dt} = k[A]^{1/3}$
The half-life period of the reaction will be
(a) $\frac{3[A_0]^{2/3}[(2)^{2/3}-1]^2}{(2)^{5/3}k}$
(b) $\frac{\frac{3}{2}[A_0]^{2/3}[(2)^{2/3}-1]}{k}$
(c) $\frac{3[A_0]^{2/3}[(2)^{2/3}-1]}{(2)^{5/3}k}$
(d) $\frac{\frac{2}{3}[A_0]^{3/2}[(2)^{2/3}-1]}{k}$

58. A compound contains atoms X, Y and Z. The oxidation number of X is +3, Y is +5 and Z is –2. The possible formula of the compound is
(a) XYZ_2 (b) $Y_2(XZ_3)_2$
(c) $X_3(YZ_4)_3$ (d) $X_3(Y_4Z)_2$

59. The standard free energy change, $\Delta G°$ is related to equilibrium constant, K_p as
(a) $K_p = -RT \ln \Delta G°$ (b) $K_p = \left(\frac{e}{RT}\right)^{\Delta G°}$
(c) $K_p = \frac{\Delta G°}{RT}$ (d) $K_p = e^{-\Delta G°/RT}$

60. Which of the following gases does not contribute to greenhouse effect?
(a) O_3 (b) H_2O vapour
(c) O_2 (d) N_2O

61. The correct order of bond angles of NO_2^+, NO_2 and NO_2^- is
(a) $NO_2^+ < NO_2 < NO_2^-$
(b) $NO_2^+ = NO_2^- < NO_2$
(c) $NO_2^+ > NO_2 > NO_2^-$
(d) $NO_2^+ > NO_2 < NO_2^-$

62. Which of the following organic compounds does not give iodoform test?
(a) CH_3CH_2OH (b) $CH_3CH_2CH_2CH_2OH$
(c) $(CH_3)_2CHOH$ (d) CH_3COCH_3

63. The order of decreasing stability of the given carbanions is
(I) $(CH_3)_3C^-$ (II) $(CH_3)_2CH^-$
(III) $CH_3CH_2^-$ (IV) $C_6H_5CH_2^-$
(a) I > II > III > IV (b) IV > III > II > I
(c) IV > I > II > III (d) I > II > IV > III

64. In the reaction,
$HCHO + CH_3MgI \rightarrow A \xrightarrow{H_2O} B + Mg(OH)I$
A and B are respectively
(a) CH_3OMgI and $CH_3 - OH$
(b) CH_3CH_2OMgI and $C_2H_5 - O - C_2H_5$
(c) CH_3CH_2OMgI and $CH_3 - CH_2 - OH$
(d) $CH_3 - CH_2 - I$ and $CH_3 - CH_2 - OH$

65. Propan-1-ol can be prepared from propene by
(a) H_2O/H_2SO_4
(b) $Hg(OAc)_2/H_2O$ followed by $NaBH_4$
(c) B_2H_6 followed by H_2O_2
(d) Br_2/H_2O

66. The coagulation value in millimoles per litre of electrolytes used for the coagulation of As_2O_3 are as given :
I. NaCl = 52 II. KCl = 5
III. $BaCl_2$ = 0.69 IV. $MgSO_4$ = 0.22
The correct order of their flocculating power is
(a) I > II > III > IV (b) I > II > III = IV
(c) IV > III > II > I (d) IV = III > II > I

67. Under two different conditions an element could be made to exist in *bcc* and *fcc* arrangements with exactly same interatomic distance. The ratio of the densities of *bcc* to *fcc* arrangements is
(a) 1 : 1 (b) 0.919 : 1
(c) 1 : 0.919 (d) 0.2 : 1

68. The hormone that controls the contraction of the uterus after child birth and releases milk from the mammary glands is
(a) oxytocin (b) vasopressin
(c) thyroxine (d) adrenaline.

69. In the balanced equation :
$H_2SO_4 + xHI \rightarrow H_2S + yI_2 + zH_2O$
the values of x, y and z are
(a) 3, 5, 2 (b) 4, 8, 5
(c) 8, 4, 4 (d) 5, 3, 4

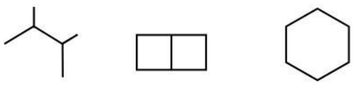
70. From the following equations, what is the heat of a hypothetical reaction, $P \longrightarrow 2Q$?
(i) $P \longrightarrow R; \Delta H_1 = x$
(ii) $R \longrightarrow S; \Delta H_2 = y$
(iii) $\frac{1}{2}S \longrightarrow Q; \Delta H_3 = z$

(a) $x + y - 2z$ (b) $x + 2y - 2z$
(c) $x + y + 2z$ (d) $x - y + 2z$

71. During the formation of the N_2O_4 dimer from two molecules of NO_2, the odd electrons, one in each of the nitrogen atoms of the NO_2 molecules, get paired to form a
(a) weak N–N bond, two N–O bonds become equivalent and the other two N–O bonds become non-equivalent.
(b) weak N–N bond and all the four N–O bonds become equivalent.
(c) weak N–N bond and all the four N–O bonds become non-equivalent.
(d) strong N–N bond and all the four N–O bonds become non-equivalent.

72. Chemical '*A*' is used for water softening to remove temporary hardness. '*A*' reacts with sodium carbonate to generate caustic soda. When CO_2 is bubbled through '*A*', it turns cloudy. What is '*A*'?
(a) $CaCO_3$ (b) CaO
(c) $Ca(OH)_2$ (d) $Ca(HCO_3)_2$

73. The numbers of monochloro derivatives obtained with $Cl_2/h\nu$ from the following :



1 2 3

are
(a) 1, 1, 1 (b) 1, 2, 1
(c) 2, 2, 1 (d) 2, 2, 2

74. For the reaction : $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$; $\Delta H = -93.6$ kJ mol^{-1}, the concentration of H_2 at equilibrium can be increased by
(a) lowering the temperature
(b) increasing the volume of the system
(c) adding N_2 at constant volume
(d) all of these.

75. Which of the following sets is named as ferrous metals?
(a) Fe, Ru, Os (b) Fe, Co, Ni
(c) Fe, Mn, Cr (d) Fe, Rh, Pt

76. Which of the following structures for a nucleotide is not correct?
(a) Cytosine-Ribose-Phosphate
(b) Uracil-2-Deoxyribose-Phosphate
(c) Uracil-Ribose-Phosphate
(d) Thymine-2-Deoxyribose-Phosphate

77. If K_1 and K_2 are the ionization constants of $H_3\overset{+}{N}CHRCOOH$ and $H_3\overset{+}{N}CHRCOO^-$ respectively, the pH of the solution at the isoelectric point is
(a) $pH = pK_1 + pK_2$
(b) $pH = (pK_1\, pK_2)^{1/2}$
(c) $pH = (pK_1 + pK_2)^{1/2}$
(d) $pH = (pK_1 + pK_2)/2$

78. Which of the following will give maximum number of isomers?
(a) $[Co(NH_3)_4Cl_2]$ (b) $[Ni(en)(NH_3)_4]^{2+}$
(c) $[Ni(C_2O_4)(en)_2]$ (d) $[Cr(SCN)_2(NH_3)_4]^{2+}$

79. An optically active amine (*A*) of molecular formula $C_4H_{11}N$ is subjected to Hoffmann's exhaustive methylation process and following hydrolysis an alkene (*B*) is produced which upon ozonolysis and subsequent hydrolysis yields formaldehyde and propanal. The amine (*A*) is
(a) $CH_3-\underset{\displaystyle NH_2}{\underset{|}{C}H}-CH_2CH_3$
(b) $CH_3-NH-\underset{\displaystyle C_2H_5}{\underset{|}{C}H}-CH_3$
(c) $CH_3-\underset{\displaystyle C_3H_7}{\underset{|}{N}}-CH_2CH_3$
(d) $CH_3CH_2CH_2CH_2-NH_2$

80. The maximum concentration of M^+ ions that can be attained in a saturated solution of M_2SO_4 at 298 K is ($K_{sp} = 1.2 \times 10^{-5}$)
(a) 7.0×10^{-3} M (b) 3.46×10^{-3} M
(c) 2.88×10^{-2} M (d) 14.4×10^{-3} M

SECTION-III (ENGLISH AND LOGICAL REASONING)

81. Complete the sentence : The higher you go, the more difficult it .... to breathe.
(a) is becoming (b) became
(c) has become (d) becomes

Direction : *In the following sentence, choose the word opposite in meaning to the bold word to fill in the blanks.*

82. **Absolute** control of the firm is what he wanted, but he ended up with .... powers.
(a) complex (b) limited
(c) little (d) few

Pick up the correct synonym.

83. Timid
(a) Veteran (b) Fearful
(c) Cowardly (d) Plucky

Direction: *In the given question, out of the four alternatives, choose the one which can be substituted for the given words/sentence.*

84. A light sailing boat built especially for racing
(a) Yacht (b) Frigate
(c) Dinghy (d) Canoe

Direction : *In the given question, a word has been written in four different ways out of which only one is correctly spelt. Find the correctly spelt word.*

85. (a) Temperature (b) Tamperature
(c) Tempereture (d) Temparature

Direction : *In the following question, find out which part of the sentence has an error.*

86. If you are great at ideas but not very good at getting into
(a) the nitty gritty /
(b) of things and implementing them, then you work on a team /
(c) that has someone who can implement.
(d) No error

Directions (Question 87 – 89) : *Read the passage and answer the following questions.*

The low unit of gas is a real temptation to anyone choosing between gas and electrical processes. But gas-fired processes are often less efficient, require more floor space, take longer and produce more variable product quality. The drawbacks negate the savings many businesses believe they make.

By contrast, electricity harnesses a unique range of technologies unavailable with gas. And many electric processes are well over 90 percent efficient, so far less energy is wasted with benefits in terms of products quality and overall cleanliness, it can so often be the better and cheaper choice. Isn't that tempting?

87. The passage can be described as an.
(a) advertisement for electricity and its efficiency
(b) extract from a science journal
(c) account of the growth of technology
(d) appeal not to use gas.

88. What does the writer mean by 'variable quality'?
(a) The quality of the products cannot be assessed.
(b) Products from gas-fired processes are inefficient.
(c) The kind of products vary from time to time.
(d) The quality of the products is not uniform.

89. "Electricity harnesses a unique range of technologies" - What does the writer mean?
Electricity ____________ .
(a) has developed new technologies
(b) ensures power for electricity and its efficiency
(c) depends on new kinds of technology
(d) makes use of several technologies

Direction : *In the following question, choose the alternative which can replace the word printed in bold without changing the meaning of the sentence.*

90. A bone got stuck in his **gullet**.
(a) Chest (b) Throat
(c) Stomach (d) Molars

Directions (Question 91 – 95) : *In each of the following questions, a sentence is given with a blank to be filled with an appropriate word. Four alternatives are suggested for each question. Choose the correct alternative.*

91. He did not register his .... to the proposal.
(a) disfavour (b) dissent
(c) deviation (d) divergence

92. Will you, like the .... gentleman and solider you are, leave at once before he finds you here?
(a) chivalrous (b) luminous
(c) barbarous (d) ostentatious

93. In these days of inflation, the cost of consumer goods is ....
(a) climbing (b) raising
(c) ascending (d) soaring

94. The Committee's appeal to the people for money .... little response.
(a) gained (b) provided
(c) evoked (d) provoked

95. The manager tried hard to .... his men to return to work before declaring a lockout.
(a) encourage (b) permit
(c) motivate (d) persuade

96. A letter series is given with two terms missing as shown by(?). Choose the missing term out of the given alternatives Z,L,X,J,V,H,T,F,?,?
(a) R,D (b) R,E (c) S,E (d) Q,D

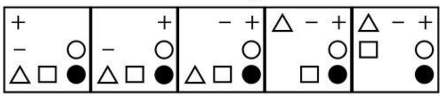
97. A matrix carrying certain numbers is given. These numbers follow a certain trend, row wise or column wise. Find out the missing number accordingly.

7	4	5
8	7	6
3	3	?
29	19	31

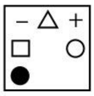
(a) 3 (b) 4 (c) 5 (d) 6

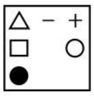
98. Which of the following options will continue the same figure as established by problem figures.

Problem Figures



A B C D E

(a)  (b) 

(c)  (d) 

99. Choose the odd numeral pair in the following question.
(a) 15 : 46 (b) 12 : 37
(c) 9 : 28 (d) 8 : 33

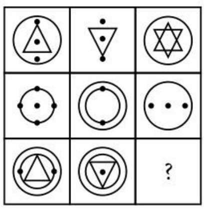
100. There are five persons P, Q, R, S and T. One is football player, one is chess player and one is hockey player. P and S are unmarried ladies and do not participate in any game. None of the ladies plays chess or football. There is a married couple in which T is the husband. Q is the brother of R and is neither a chess player nor a hockey player.
Who is the football player?
(a) P (b) Q (c) R (d) S

101. In a certain coding system, '816321' means '*the brown dog frightened the cat*'; '64851' means '*the frightened cat ran away*'; '7621' means '*the cat was brown*'; '341' means '*the dog ran*'. What is the code for '*the dog was frightened*'?
(a) 5438 (b) 8263
(c) 8731 (d) none of these

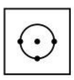
102. Victory : Encouragement : : Failure : ?
(a) Sadness (b) Defeat
(c) Anger (d) Frustration

103. If '+' means 'divided by', '_' means 'added to', '×' means 'subtracted from' and '÷' means 'multiplied by', then what is the value of 24 ÷ 12 – 18 + 9 ?
(a) – 25 (b) 0.72 (c) 15.30 (d) 290

104. In the following question, find out which of the answer figures (a), (b), (c) and (d) completes the figure matrix ?



(a)  (b) 

(c)  (d) 

105. Find out which of the figures (a), (b), (c) and (d) can be formed from the pieces given in fig. (X).

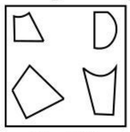
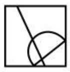


Fig.(X)

(a)  (b)  (c)  (d) 

SECTION-IV (MATHEMATICS)

106. A chord of the hyperbola $4x^2 - 9y^2 = 36$ is bisected at the point (3, 5). The distance of the origin from the chord is

(a) $\frac{63}{\sqrt{241}}$ (b) $\frac{50}{\sqrt{241}}$ (c) $\frac{13}{\sqrt{19}}$ (d) $\frac{13}{\sqrt{190}}$

107. Triangles are formed with vertices of a regular polygon of 20 sides. The probability that no side of the polygon is a side of the triangle, is

(a) $\frac{25}{57}$ (b) $\frac{30}{57}$ (c) $\frac{35}{57}$ (d) $\frac{40}{57}$

108. Let $\vec{a}, \vec{b}, \vec{c}, \vec{d}$ be such that $(\vec{a}\times b)\times(\vec{c}\times\vec{d})=0$. Let p_1 and p_2 be the planes determined by the pairs of vectors, $\vec{a}, \vec{b}$ and $\vec{c}, \vec{d}$ respectively. The angle between the planes p_1 and p_2 is

(a) 0 (b) $\frac{\pi}{4}$ (c) $\frac{\pi}{3}$ (d) $\frac{\pi}{2}$

109. Let $f(x) = [x]\sin\frac{\pi}{[x+1]}$. The points of discontinuity are

(a) Z (b) Z – {0} (c) Z – {1} (d) Z– {–1}

110. The normal at any point $P(x, y)$ on a curve meets the x-axis at N. If $OP = PN$, where O is the origin, then the curve is a/an
(a) circle (b) parabola
(c) ellipse (d) none of these

111. Two mappings $f : R \to R$ and $g : R \to R$ are defined in the following ways : $f(x)=\begin{cases}0, \text{ when } x \text{ is rational}\\ 1, \text{ when } x \text{ is irrational}\end{cases}$

$g(x)=\begin{cases}-1, \text{ when } x \text{ is rational}\\ 0, \text{ when } x \text{ is irrational}\end{cases}$

Then the value of $(gof)(e) + (fog)(\pi)$ is

(a) –1 (b) 1 (c) 0 (d) 2

112. If $\int_{\sin^{-1}a}^{\sin^{-1}b} dx = \int_{2a}^{2b} \frac{\sqrt{4-x^2}\, f\left(\frac{x}{2}\right)-1}{\sqrt{4-x^2}}\, dx$ then which is incorrect ?

(a) $f\left(\frac{1}{2}\right)=\frac{2}{\sqrt{3}}$ (b) $f\left(\frac{1}{3}\right)=\frac{3}{2\sqrt{2}}$

(c) $f\left(\frac{1}{4}\right)=\frac{4}{\sqrt{15}}$ (d) none of these

113. The number $\log_2 7$ is

(a) an integer (b) prime

(c) rational (d) irrational

114. The differential equation $\frac{dy}{dx}=\frac{\sqrt{1-y^2}}{y}$ determines a family of circles with

(a) variable radii and a fixed centre (0, 1)

(b) variable radii and a fixed centre (0, –1)

(c) fixed radius 1 and variable centres along the x-axis

(d) fixed radius 1 and variable centres along the y-axis

115. Find the general solution for

$|\sin\theta - \cos^2\theta| \geq |\sin^2\theta - 3\sin\theta + 3| + 4|1 - \sin\theta|$.

(a) $n\pi;\ n\in I$ (b) $2n\pi;\ n\in I$

(c) $(4n+1)\frac{\pi}{2};\ n\in I$ (d) none of these

116. The number of integers greater than 6000 that can be formed with 3, 5, 6, 7 and 8, where no digit is repeated, is

(a) 120 (b) 192 (c) 216 (d) 72

117. $\sec^2(\tan^{-1} 2) + \text{cosec}^2(\cot^{-1} 3)$ is equal to

(a) 1 (b) 5 (c) 10 (d) 15

118. $\int_0^{\frac{\pi}{2}} \frac{(\sin x+\cos x)^2}{\sqrt{1+\sin 2x}}\,dx=$

(a) 0 (b) 1 (c) 2 (d) 3

119. If $\tan 25° = a$, then the value of $\frac{\tan 205° - \tan 115°}{\tan 245° + \tan 335°}$ in terms of a is

(a) $\frac{1+a^2}{a^2-1}$ (b) $\frac{1+a^2}{1-a^2}$

(c) $\frac{1-a^2}{1+a^2}$ (d) $\frac{a^2-1}{1+a^2}$

120. α, β are roots of $ax^2 + 2bx + c = 0$ and γ, δ are the roots of $px^2 + 2qx + r = 0$. If $\alpha, \beta, \gamma, \delta$ are in A.P., then $\frac{b^2-ac}{q^2-pr}$ equals

(a) $\frac{a^2}{p^2}$ (b) $\frac{b^2}{q^2}$

(c) $\frac{c^2}{r^2}$ (d) none of these

121. In a triangle ABC, angle A is greater than angle B. If the measures of angles A and B satisfy the equation $3\sin x - 4\sin^3 x - k = 0$, $0 < k < 1$, then the measure of angle C is

(a) $\frac{\pi}{3}$ (b) $\frac{\pi}{2}$ (c) $\frac{2\pi}{3}$ (d) $\frac{5\pi}{6}$

122. The number of integral values of k for which the equation $7\cos x + 5\sin x = 2k + 1$ has a solution is

(a) 4 (b) 8 (c) 12 (d) 10

123. If $f(x)=\frac{x}{x-1}, x\neq 1$, then $\underbrace{(fofo.....of)(x)}_{\text{19 times}}$ is equal to

(a) $\frac{x}{x-1}$ (b) $\left(\frac{x}{x-1}\right)^{19}$

(c) $\frac{19x}{x-1}$ (d) x

124. If $\frac{dy}{dx}=\frac{x-y}{x+y}, y(1)=1$, then $(y(0))^2=$

(a) 1 (b) 2 (c) 3 (d) 4

125. Let α and β be the roots of the equation $x^2+x+1=0$. The equation whose roots are α^{19}, β^7 is

(a) $x^2 - x - 1 = 0$ (b) $x^2 - x + 1 = 0$

(c) $x^2 + x - 1 = 0$ (d) $x^2 + x + 1 = 0$

126. The value of $n \in I$ for which the function $f(x)=\frac{\sin nx}{\sin(x/n)}$ has 4π as its period, is

(a) 2 (b) 3 (c) 4 (d) 5

127. There are 3 copies each of 4 different books. The number of ways they can be arranged in a shelf is

(a) 369600 (b) 400400

(c) 420600 (d) 440720

128. Line L has intercepts a and b on the coordinate axes. When the axes are rotated through a given angle, keeping the origin fixed, the same line L has intercepts p and q, then

(a) $a^2 + b^2 = p^2 + q^2$ (b) $\frac{1}{a^2}+\frac{1}{b^2}=\frac{1}{p^2}+\frac{1}{q^2}$

(c) $a^2 + p^2 = b^2 + q^2$ (d) $\frac{1}{a^2}+\frac{1}{p^2}=\frac{1}{b^2}+\frac{1}{q^2}$

129. The sum $\sum_{i=0}^{m}\binom{10}{i}\binom{20}{m-i}$ (where $\binom{p}{q}=0$ if $p<q$) is maximum where m is

(a) 5 (b) 10 (c) 15 (d) 20

130. If $\cos\theta = \frac{-3}{5}$ and $\pi < \theta < \frac{3\pi}{2}$, then the value of $\frac{\operatorname{cosec}\theta + \cot\theta}{\sec\theta - \tan\theta}$ is

(a) 1/6 (b) 1/7 (c) 1/5 (d) 1/2

131. If $xy = m^2 - 9$ be a rectangular hyperbola whose branches lie only in the second and fourth quadrant, then

(a) $|m| \geq 3$ (b) $|m| < 3$
(c) $m \in R - \{|m|\}$ (d) none of these

132. Let S be the sum, P be the product and R be the sum of the reciprocals of n terms of a G.P. Then $R^nP^2 : S^n$ is equal to

(a) (first term)^2 : (common ratio)^n
(b) 1 : 1
(c) (common ratio)^n : 1
(d) None of these

133. Let $\vec{a} = \alpha_1\hat{i} + \alpha_2\hat{j} + \alpha_3\hat{k}$, $\vec{b} = \beta_1\hat{i} + \beta_2\hat{j} + \beta_3\hat{k}$, $\vec{c} = \gamma_1\hat{i} + \gamma_2\hat{j} + \gamma_3\hat{k}$ and $|\vec{a}| = 2\sqrt{2}$ makes the angle $\frac{\pi}{3}$ with the plane of $\vec{b}$ & $\vec{c}$ and angle between $\vec{b}$ and $\vec{c}$ is $\frac{\pi}{6}$, then the value of $\begin{vmatrix} \alpha_1 & \alpha_2 & \alpha_3 \\ \beta_1 & \beta_2 & \beta_3 \\ \gamma_1 & \gamma_2 & \gamma_3 \end{vmatrix}^n$ equals

(a) $\left(\frac{|a||b|}{2\times 3}\right)^n$ (b) $\left(\frac{|\vec{c}||\vec{b}|}{\sqrt{3}\times 2}\right)^{n/2}$

(c) $\left(\frac{\sqrt{3}|\vec{b}||\vec{c}|}{\sqrt{2}}\right)^n$ (d) none of these

134. For any vector $\vec{a}$, prove that $|\vec{a}\times\hat{i}|^2 + |\vec{a}\times\hat{j}|^2 + |\vec{a}\times\hat{k}|^2$ is equal to

(a) $2|\vec{a}|^2$ (b) $|\vec{a}|^2$ (c) $3|\vec{a}|^2$ (d) $4|\vec{a}|^2$

135. $\int \frac{dx}{\sqrt{x} - \sqrt[3]{x}} =$

(a) $2x^{1/2} + 3x^{1/3} + x^{1/6} + \ln x + C$
(b) $2x^{1/2} + 3x^{1/3} + 6x^{1/6} + 6\ln x + C$
(c) $2x^{1/2} + 3x^{1/3} + 6\,x^{1/6} + 6\ln|x^{1/6} - 1| + C$
(d) none of these

136. The first 12 letters of English alphabet are written in a row at random. The probability that there are exactly four letters in between A and B is

(a) $\frac{5}{66}$ (b) $\frac{1}{22}$ (c) $\frac{7}{66}$ (d) $\frac{1}{11}$

137. If $<l_1, m_1, n_1>$ and $<l_2, m_2, n_2>$ are the direction cosines of two rays $\overrightarrow{OP}$ and $\overrightarrow{OQ}$ enclosing an angle θ, then the d.c. of the bisector of $\angle POQ$ are

(a) $<\frac{l_1+l_2}{2\cos(\theta/2)}, \frac{m_1+m_2}{2\cos(\theta/2)}, \frac{n_1+n_2}{2\cos(\theta/2)}>$

(b) $<\frac{l_1+l_2}{2\sin(\theta/2)}, \frac{m_1+m_2}{2\sin(\theta/2)}, \frac{n_1+n_2}{2\sin(\theta/2)}>$

(c) $<\frac{l_1-l_2}{2\cos(\theta/2)}, \frac{m_1-m_2}{2\cos(\theta/2)}, \frac{n_1-n_2}{2\cos(\theta/2)}>$

(d) $<\frac{l_1-l_2}{2\sin(\theta/2)}, \frac{m_1-m_2}{2\sin(\theta/2)}, \frac{n_1-n_2}{2\sin(\theta/2)}>$

138. Solution of the differential equation $ye^{\frac{x}{y}}dx = (xe^{\frac{x}{y}} + y^2)dy \ (y \neq 0)$ is

(a) $e^{\frac{x}{y}} = y + C$ (b) $e^{\frac{x}{y}} = x + C$
(c) $e^x + y = C$ (d) $e^y = x + C$

139. Maximize $Z = 10x_1 + 25x_2$, subject to $0 \leq x_1 \leq 3$, $0 \leq x_2 \leq 3$, $x_1 + x_2 \leq 5$.

(a) 80 at (3, 2) (b) 75 at (0, 3)
(c) 30 at (3, 0) (d) 95 at (2, 3)

140. $\int 2^{2^{2^x}} \cdot 2^{2^x} \cdot 2^x dx =$

(a) $2^{2^{2^x}} \cdot (\ln 2)^3 + C$ (b) $2^{2^x} \cdot (\ln 2)^2 + C$

(c) $\frac{2^{2^{2^x}}}{(\ln 2)^3} + C$ (d) none of these

141. In any discrete series when all values are not same, the relation between M.D. about mean and S.D. is

(a) M.D. = S.D. (b) M.D. ≥ S.D.
(c) M.D. < S.D. (d) M.D. ≤ S.D.

142. The relation S defined on the set $N \times N$ by $(a, b)\ S(c, d) \Rightarrow a + d = b + c$ is an

(a) equivalence relation
(b) reflexive but not symmetric
(c) only transitive
(d) only symmetric

143. For all $n \in N$, $41^n - 14^n$ is a multiple of

(a) 26 (b) 27
(c) 25 (d) none of these

144. If $\int_a^x f(t)dt - \int_0^y g(t)dt = b$, then the value of $\frac{dy}{dx}$ at (x_0, y_0), is

(a) $\frac{f(x_0)}{g(y_0)}$ (b) $\frac{g(x_0)}{f(y_0)}$

(c) $g(x_0) - f(y_0)$ (d) $f(x_0) - g(y_0)$

145. Evaluate $\int \frac{\sqrt{\tan x}}{\sin x \cdot \cos x} dx$

(a) $3\sqrt{\tan x} + c$ (b) $\sqrt{\tan x} + c$

(c) $2\sqrt{\tan x} + c$ (d) $\frac{\sqrt{\tan x}}{2} + c$

146. The curve described parametrically by $x = t^2 + t + 1$, $y = t^2 - t + 1$ represents

(a) a pair of straight lines
(b) an ellipse
(c) a parabola
(d) a hyperbola.

147. Which of the following is/are true?

(i) The principal value of $\cos^{-1}\frac{\sqrt{3}}{2}$ is $\frac{\pi}{6}$.

(ii) The principal value of $\text{cosec}^{-1}(2)$ is $\frac{\pi}{4}$.

(iii) The principal value of $\tan^{-1}(-\sqrt{3})$ is $\frac{-\pi}{3}$.

(a) (i), (ii) (b) (ii), (iii)
(c) (i), (iii) (d) (i), (ii), (iii)

148. If the trace of the matrix

$$A = \begin{bmatrix} x-1 & 0 & 2 & 5 \\ 3 & x^2-2 & 4 & 1 \\ -1 & -2 & x-3 & 1 \\ 2 & 0 & 4 & x^2-6 \end{bmatrix}$$ is 0, then x is equal to

(a) {2, 3} (b) {–2, –3}
(c) {–3, 2} (d) {1, 2}

149. If polar of $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ is always touching the circle $x^2 + y^2 = c^2$, then locus of pole is

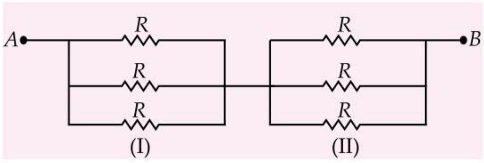
(a) $c^2(a^4y^2 + b^4x^2) = a^4b^4$
(b) $c^2(a^4x^2 + b^4y^2) = a^4b^4$
(c) $c^2(a^4y^2 + b^4x^2 - a^3b^3) = a^4b^4$
(d) none of these

150. $\lim_{x \to \frac{\pi}{4}} (\tan x)^{\tan 2x}$ equals

(a) e (b) e^2 (c) e^{-1} (d) e^{-2}

SOLUTIONS

1. (b) : The simplified circuit is given here.



In section I, three resistors each of resistance R are connected in parallel. The equivalent resistance R' is given by

$\frac{1}{R'} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R}$ or $R' = \frac{R}{3}$

Similarly in section II, three resistors each of resistance R are connected in parallel. The equivalent resistance R'' is given by

$R'' = \frac{R}{3}$

Since R' and R'' are connected in series, the equivalent resistance between A and B is given by

$R_{eq} = R' + R'' = \frac{R}{3} + \frac{R}{3} = \frac{2R}{3}$

2. (d) : $H_1 = \frac{u^2 \sin^2\theta}{2g}$, $H_2 = \frac{u^2 \sin^2(90-\theta)}{2g} = \frac{u^2\cos^2\theta}{2g}$

$R = \frac{u^2 \sin 2\theta}{g}$

$H_1 H_2 = \frac{u^2\sin^2\theta}{2g} \times \frac{u^2\cos^2\theta}{2g}$

$= \frac{u^4 \sin^2\theta\cos^2\theta}{4g^2} = \frac{u^4(4\sin^2\theta\cos^2\theta)}{16g^2} = \frac{R^2}{16} \Rightarrow R = 4\sqrt{H_1H_2}$

3. (d) : By Stefan's law, rate of heat emission, $\frac{dQ}{dt} = A\sigma\left(T^4 - T_0^4\right)$

Since T, T_0 and σ are same for the two bodies , hence

$$\frac{\left(\frac{\Delta Q}{dt}\right)_1}{\left(\frac{\Delta Q}{dt}\right)_2} = \frac{R_1^2}{R_2^2}$$

Rate of heat loss is given by

$\frac{dQ}{dt} = mC\left(\frac{\Delta T}{dt}\right) = \rho VC\left(\frac{\Delta T}{dt}\right) = \rho\frac{4}{3}\pi R^3 C\left(\frac{\Delta T}{dt}\right)$

$$\therefore \frac{\frac{4}{3}\pi R_1^3\rho_1C_1\left(\frac{dT}{dt}\right)_1}{\frac{4}{3}\pi R_2^3\rho_2C_2\left(\frac{dT}{dt}\right)_2} = \frac{R_1^2}{R_2^2} \Rightarrow \frac{(dT/dt)_1}{(dT/dt)_2} = \frac{R_2\rho_2C_2}{R_1\rho_1C_1}$$

4. (b) : Magnetic field at the centre of current carrying circular coil, $B = \frac{\mu_0 I}{2r}$

Magnetic moment μ of electron revolving in circular orbit is given by $\frac{\mu}{L} = \frac{e}{2m}$ $\therefore$ $\frac{I \times \pi r^2}{L} = \frac{e}{2m}$

$I = \frac{e}{2m}\frac{L}{\pi r^2}$ $\therefore$ $B = \frac{\mu_0 e L}{4\pi r^3 m}$

5. **(c)** : As $g=\frac{GM}{R^2}$

$\therefore \quad \frac{\Delta g}{g}=-2\frac{\Delta R}{R}=-2\times 1.5=-3\%$

6. **(d)** : When the entire arrangement of Young's double slit experiment is placed in a liquid of refractive index μ, then the fringe width will become

$$\beta'=\frac{\lambda' D}{d}=\frac{\lambda D}{\mu d}=\frac{\beta}{\mu} \qquad \left(\because \ \beta=\frac{\lambda D}{d}\right)$$

7. **(a)** : Given, $A_m = 5$ V, $A_c = 20$ V

$\therefore \quad$ Modulation index, $\mu=\frac{A_m}{A_c}=\frac{5}{20}=0.25$

8. **(d)** : Capacitor gets discharged as per the relation, $I=\frac{V_0}{R}e^{-t/RC}$

$$\ln I=\ln\frac{V_0}{R}-\frac{t}{RC}$$

In both cases log of initial current is same that means $\frac{V_0}{R}$ is constant. To keep $\frac{V_0}{R}$ constant, both V_0 and R have to be changed whereas it is stated that only one parameter out of V_0, R and C is changed. Therefore only C has been changed and to match the straight line in the graph, it is decreased.

9. **(b)** : At zero degree kelvin, molecular motion stops. Velocity is zero. Hence kinetic energy is zero.

10. **(b)** : Inside pressure must be $\frac{4T}{r}$ greater than outside pressure in bubble. This excess pressure is provided by charge on bubble.

$$\frac{4T}{r}=\frac{\sigma^2}{2\varepsilon_0} \Rightarrow \frac{4T}{r}=\frac{Q^2}{16\pi^2 r^4\times 2\varepsilon_0} \qquad \left[\because \sigma=\frac{Q}{4\pi r^2}\right]$$

$$Q=8\pi r\sqrt{2rT\varepsilon_0}$$

11. **(b)** : $\Delta U=nC_V\Delta T=\left(\frac{R}{\gamma-1}\right)n\Delta T$

$$\Rightarrow \Delta U=\frac{P\Delta V}{(\gamma-1)}=\frac{P(2V-V)}{(\gamma-1)}=\frac{PV}{\gamma-1}$$

12. **(d)**

13. **(d)** : For the given wave, wave-velocity, $v=\lambda\upsilon$

Maximum particle velocity, $v_p = a\omega = 2\pi\,\upsilon y_0$

where a = maximum amplitude

$$\frac{v_p}{v}=\frac{2\pi\upsilon y_0}{\upsilon\lambda}=\frac{2\pi y_0}{\lambda}$$

$$\therefore \ 4=\frac{2\pi y_0}{\lambda} \Rightarrow \lambda=\frac{2\pi y_0}{4}=\frac{\pi y_0}{2}$$

14. **(c)**

15. **(d)** : Either $\upsilon_A=\upsilon_B+5$ or $\upsilon_A=\upsilon_B-5$

By filing, υ_A increases. Since beats per second increase, the choice is only $\upsilon_A=\upsilon_B+5=512+5=517$ Hz

16. **(b)** : K.E. $=\frac{1}{2}mv^2=\beta x^2$ or $v^2=\frac{2\beta x^2}{m}$

Differentiate w.r.t. to x, $2v\frac{dv}{dx}=\frac{4\beta x}{m}$

or $v\frac{dv}{dx}=\frac{2\beta x}{m}$

Radial acceleration $= a_R = \frac{v^2}{R}=\frac{2\beta x^2}{mR}$

Tangential acceleration $= a_T=\frac{dv}{dt}=\frac{dv}{dx}\cdot v$

$\therefore \ a_T=\frac{2\beta x}{m}$

Total force = mass × acceleration

$$=m\sqrt{a_R^2+a_T^2}=m\cdot\sqrt{\left(\frac{2\beta x^2}{mR}\right)^2+\left(\frac{2\beta x}{m}\right)^2}=2\beta x\sqrt{1+\frac{x^2}{R^2}}$$

17. **(b)** 18. **(c)** 19. **(d)**

20. **(a)** : For $0\le x\le 1$, K.E. $=2E_0-E_0=E_0$

For $x>1$, K.E. $=2E_0$

$$\frac{\lambda_1}{\lambda_2}=\frac{h/p_1}{h/p_2}=\frac{p_2}{p_1}=\sqrt{\frac{\text{K.E.}_2}{\text{K.E.}_1}}=\sqrt{\frac{2E_0}{E_0}}=\sqrt{2}$$

21. **(a)** : Maximum height from inclined plane is

$$H=\frac{u_\perp^2}{2a_\perp}=\frac{(10\sin 37^\circ)^2}{2g\cos 53^\circ}=3\,\text{m}$$

22. **(b)**

23. **(c)** : Equate volumes, $\frac{4}{3}\pi R^3=n\times\frac{4}{3}\pi r^3$

$\therefore \quad R^3=nr^3$

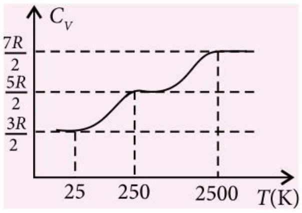
Change in surface energy $=T\,[n.4\pi r^2-4\pi R^2]=4\pi T\,(nr^2-R^2)$

$$\frac{\text{Change in energy}}{\text{volume}}=\frac{4\pi T}{\frac{4}{3}\pi R^3}(nr^2-R^2)$$

$$=\frac{3T}{R^3}(nr^2-R^2)=3T\left(\frac{nr^2}{R^3}-\frac{1}{R}\right)=3T\left(\frac{1}{r}-\frac{1}{R}\right)$$

Rise in heat energy per unit volume $=\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

24. **(c)** : C_V for H_2 gas is varying in given temperature range, so the temperature of the gas is not increasing at constant rate. Here, in the shown diagram, temperature is on the logarithmic scale.



$$dT=\frac{dQ}{nC_V}$$

Since for the initial portion C_V is small, so dT is greatest.

25. **(d)** : When a ring moves in a magnetic field perpendicular to its plane, replace the ring by a diameter perpendicular to the direction of motion. The emf is induced across this diameter.

Induced emf, $\varepsilon = B(2r)v$

In the question, current flow in the ring will be through the two semicircular portions, in parallel.

Resistance of each half of the ring $= R/2$

As these are in parallel, the equivalent resistance $= R/4$

Current in the circuit $=\frac{B(2r)v}{(R/4)}=\frac{8Brv}{R}$

26. (b) : Work done by electric field $= q\int_r^{2r} \frac{2k\lambda}{r} dr = q2k\lambda \ln 2$

$\therefore\ 2k\lambda q \ln 2 = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{\lambda q \ln 2}{m\pi\varepsilon_0}}$

27. (c) : Maximum linear momentum = m × maximum velocity

$p_{\max} = m \times v_{\max}$ or $p_x = mv_x$

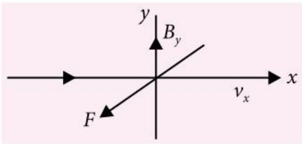
$\therefore\ E$ = total energy = Maximum K.E.= $\frac{1}{2}m\,(v_x)^2$

$E = \frac{1}{2}m\cdot\left(\frac{p_x}{m}\right)^2 = \frac{1}{2}\frac{mp_x^2}{m^2} = \frac{p_x^2}{2m}$

$p_x^{\ 2} = 2mE$ or $p_x = \sqrt{2mE}$

28. (c) **29. (a)**

30. (b) : The force on a charged particle e due to a magnetic field is given by $\vec{F} = e(\vec{v}\times\vec{B})\cdot$



Here $\vec{v} = v_x\hat{i}$ and $\vec{B} = B_y\hat{j}$

$\therefore\ \vec{F} = ev_x B_y(\hat{i}\times\hat{j}) = ev_x B_y\hat{k}$

Therefore the subsequent motion of the charged particle will be a circle in the xz plane.

31. (a)

32. (a) : Given : $\alpha = 0.9$

$\therefore\ \beta = \frac{\alpha}{1-\alpha} = \frac{0.9}{1-0.9} = 9$

As $\beta = \frac{I_C}{I_B}$ $\therefore\ I_C = \beta I_B = 9(2\ \mu\text{A}) = 18\ \mu\text{A}$

33. (b) : Given : $p = p_0 e^{-\alpha t^2}$

αt^2 is a dimensionless

$\therefore\ [\alpha] = \frac{1}{[t^2]} = \frac{1}{[\mathrm{T}^2]} = [\mathrm{T}^{-2}]$

34. (d)

35. (c) : From Doppler's effect, $\upsilon' = \frac{\upsilon(v - v_o)}{(v - v_s)}$

Here v_o and v_s are in direction of v.

$\upsilon = 256$ Hz, $v_s = \frac{v}{3}$, $v_o = 0$

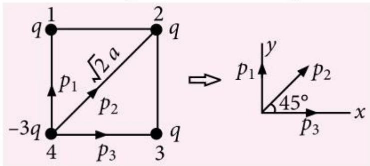
$\upsilon' = \frac{256(v)}{v - \frac{v}{3}} = \frac{256\,v\times 3}{2v} = 384$ Hz

36. (a) : $g = \frac{GM}{R^2} = G\cdot\frac{4}{3}\frac{\pi R^3\cdot\rho}{R^2} = \frac{4\pi\rho G}{3}\cdot R$

$\frac{g_1}{g_2} = \frac{R_1}{R_2}$

37. (a) : The possible quantity of heat that will be released by 540 g of water at 80°C cooling down to 0°C, is 540 × 1 × 80 = 540 × 80 cal. To melt 540 g of ice at 0°C heat required = 540 × 80 cal. Hence the mixture will remain at 0°C.

38. (b) : From vector diagram shown in figure,



$p_1 = qa = p_3,\ p_2 = \sqrt{2}qa$

$p_x = p_3 + p_2\cos 45° = qa + \sqrt{2}qa\frac{1}{\sqrt{2}} = 2qa$

$p_y = p_1 + p_2\cos 45° = 2qa$

$\therefore\ p = \sqrt{p_x^2 + p_y^2} = 2\sqrt{2}qa$

39. (b) : In the second excited state, $n = 3$

$\therefore\ l_{\mathrm{H}} = l_{\mathrm{Li}} = 3\left(\frac{h}{2\pi}\right)$

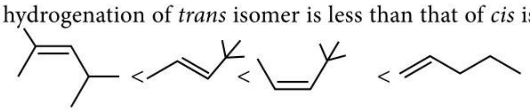
$Z_{\mathrm{H}} = 1,\ Z_{\mathrm{Li}} = 3,\ E \propto Z^2$

$\therefore\ |E_{\mathrm{Li}}| = 9|E_{\mathrm{H}}|$ or $|E_{\mathrm{H}}| < |E_{\mathrm{Li}}|$

40. (a) : When a constant current is flowing through a conductor of non-uniform cross-section, electron density does not depend upon the area of cross section, while current density, drift velocity and electric field all vary inversely with area of cross-section.

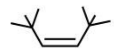
41. (c) : Greater the stability of alkene, lower is the heat of hydrogenation.

Out of *cis* and *trans* isomers, *trans* isomer is more stable than *cis* isomer in which two alkyl groups lie on the same side of the double bond and hence cause steric hindrance, therefore, heat of hydrogenation of *trans* isomer is less than that of *cis* isomer.



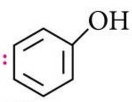
V 7-hyperconjugative hydrogens < IV 3-hyperconjugative hydrogens < III < I 2-hyperconjugative hydrogens

<

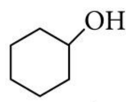


II No hyperconjugative hydrogens

42. (d) :



and



Both will liberate H_2 gas with Na metal.

43. (c) : $\frac{1}{2}mv^2 = h(\upsilon - \upsilon_0) = h\left(\frac{c}{\lambda} - \frac{c}{\lambda_0}\right)$

$= hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = hc\left(\frac{\lambda_0 - \lambda}{\lambda_0\lambda}\right)$

or $v^2 = \frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda_0\lambda}\right)$ or $v = \left[\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda_0\lambda}\right)\right]^{1/2}$

44. (d) : $10e^- + (\mathrm{V}^{+5})_2 \longrightarrow 2\mathrm{V}^0$

$\therefore\ E = \frac{M}{10} = \frac{2A + 80}{10}$

45. **(a)** : At anode : $Cl^- \longrightarrow \frac{1}{2}Cl_2 + e^-$

At cathode : $\frac{1}{2}Cl_2 + e^- \longrightarrow Cl^-$

$[Cl^-]$ at anode = x M

At cathode, $[Ag^+][Cl^-] = K_{sp}$

$$\Rightarrow \quad [Cl^-] = \sqrt{K_{sp}} \qquad (\because [Ag^+] = [Cl^-])$$

$$E_{cell} = E^\circ_{cell} - \frac{0.059}{n}\log\frac{[Cl^-]_{cathode}}{[Cl^-]_{anode}}$$

$$= 0 - \frac{0.059}{1}\log\frac{\sqrt{K_{sp}}}{x} = +\,0.059\log\frac{x}{\sqrt{K_{sp}}}$$

46. **(a)** : The stability of a complex compound is measured in terms of the stability constant. Higher the value of stability constant, more stable will be the compound. Thus, the complex with stability constant value 1.6×10^7 is the least stable compound.

47. **(d)** : In a buffer, there are (i) weak acid and its conjugate base or (ii) weak base and its conjugate acid

In (d), 0.100 mol of HCl will convert 0.100 mol of aniline into anilinium ion, mixture will contain 0.100 mol of aniline and 0.100 mol of anilinium salt. Hence it is a buffer.

48. **(b)** : $-nFE^\circ_{cell} = -RT\ln K$ or $E^\circ_{cell} = \frac{RT}{nF}\ln K$

Plot of E°_{cell} *vs* $\ln K$ will have slope $\frac{1}{2}\frac{RT}{F}$.

49. **(c)** : $P = 0.658$ atm, $T = 373$ K, $w = 0.553$ g

$$V = \frac{407}{1000}\text{ L}$$

$$M = \frac{wRT}{PV} = \frac{0.553 \times 0.0821 \times 373}{0.658 \times 407/1000} = 63.23$$

$\therefore$ 100 g compound has B = 85.7 g

$\therefore$ 63.23 g compound has B $= \frac{85.7 \times 63.23}{100} = 54.2$

$\frac{54.2}{10.8}$ g atom of B = 5 g atom of B

Formula is B_5H_x

$\therefore \quad 5 \times 10.8 + x = 63.23$ or $x = 9.23 \simeq 9$

$\therefore$ Mol. formula of the compound is B_5H_9.

50. **(a)** : Given; $w = 5$ g, $V = 100$ mL, $\pi = 7$ atm, $M = 180$ g mol^{-1}

Applying $\pi V = \frac{w}{M}\cdot RT$

$$7 \times \frac{100}{1000} = \frac{5}{180} \times 0.0821 \times T \Rightarrow T = \frac{7 \times 100 \times 180}{1000 \times 5 \times 0.0821} = 306.94 \text{ K or } 33.94\ °C$$

51. **(c)**

52. **(a)** : For an isothermal process

PV = constant

$P_1V_1 = P_2V_2$

$$PV = P_I \times 2V \quad \text{or} \quad \frac{P}{P_I} = 2 \qquad \ldots(i)$$

For an adiabatic process

PV^γ = constant $\qquad (\gamma = 1.67)$

$$PV^\gamma = P_{II}(2V)^\gamma \text{ or } \frac{P}{P_{II}} = 2^\gamma \qquad \ldots(ii)$$

Dividing equation (i) by (ii)

$$\frac{P_{II}}{P_I} = \frac{2}{2^\gamma} \text{ or } \frac{P_{II}}{P_I} = \frac{1}{2^{\gamma-1}} = \frac{1}{(2)^{0.67}}$$

53. **(c)** : Dacron (terylene) is a polymer of ethylene glycol and terephthalic acid.

54. **(b)**

55. **(b)** : For transformations $L \rightarrow M$ and $N \rightarrow K$, volume is constant.

56. **(d)** : Alkaline earth metals are group 2 elements. Emission of α-particle ($_2^4He$) will reduce its atomic number by 2 units and thus, displaces the daughter nuclei two positions left in the periodic table, thus to group 18, 16, 14, 12, 10, 8, 6 or 4, etc. As the last stable daughter nuclei formed could be either Pb (group 14) or Bi (group 15) therefore, the daughter nuclei would belong to group 14.

57. **(c)**

58. **(c)** : Sum of oxidation numbers of all the atoms in $X_3(YZ_4)_3$ is zero *i.e.*, $3 \times (+3) + 3\,[1 \times (+5) + 4 \times (-2)] = 9 - 9 = 0$

In all other compounds, the sum of oxidation numbers is a finite number.

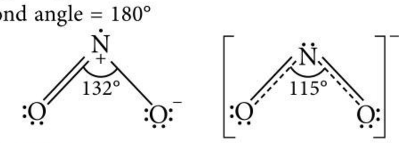
59. **(d)**

60. **(c)** : Oxygen gas does not contribute to greenhouse effect.

61. **(c)** : The bond angles of NO_2, NO_2^+ and NO_2^- are in the order $NO_2^+ > NO_2 > NO_2^-$. This is because NO_2^+ has no unshared electron and hence it is linear. NO_2 has one unshared electron while NO_2^- has one unshared electron pair.

$:\ddot{O}=\overset{+}{N}=\ddot{O}:$

Bond angle = 180°

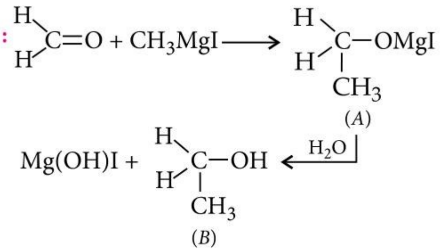


62. **(b)** : $CH_3CH_2CH_2CH_2OH$ does not give iodoform test since it does not contain $CH_3CH(OH)$— or CH_3CO— group.

63. **(b)** : Order of stability of carbanions is 1° > 2° > 3°, but $C_6H_5CH_2^-$ is most stable due to resonance stabilisation. Thus, order of stability is :

$$\underset{(IV)}{C_6H_5CH_2^-} > \underset{(III)}{CH_3CH_2^-} > \underset{(II)}{(CH_3)_2CH^-} > \underset{(I)}{(CH_3)_3C^-}$$

64. **(c)** :



65. **(c)** : Hydroboration-oxidation gives anti - Markownikoff's product.

$$\underset{\text{Propene}}{CH_3-CH=CH_2} \xrightarrow[\text{(ii) } H_2O_2/OH^-]{\text{(i) } B_2H_6} \underset{\text{Propan-1-ol}}{CH_3-CH_2-CH_2OH}$$

66. (c) : Smaller the coagulation value of an electrolyte, greater is its coagulating or precipitating power. Therefore, the correct order is IV > III > II > I.

67. (b) : For *bcc*, $4r = \sqrt{3}\,a_1$ and $Z_1 = 2$

For *fcc*, $4r = \sqrt{2}\,a_2$ and $Z_2 = 4$

For equal interatomic distance,

$\sqrt{3}\,a_1 = \sqrt{2}\,a_2$

$$\frac{a_2}{a_1} = \frac{\sqrt{3}}{\sqrt{2}}\ ;\ \frac{d_1}{d_2} = \frac{\dfrac{MZ_1}{a_1^3 N_0}}{\dfrac{MZ_2}{a_2^3 N_0}} = \frac{a_2^3 Z_1}{a_1^3 Z_2}$$

$$= \left(\sqrt{\frac{3}{2}}\right)^3 \times \frac{2}{4} = \frac{\left(\sqrt{1.5}\right)^3}{2} = \frac{0.919}{1}$$

68. (a)

69. (c) :

$$\overset{+6}{H_2SO_4} + \overset{-1}{HI} \longrightarrow \overset{-2}{H_2S} + \overset{0}{I_2} + H_2O$$

Decrease in O.N. = 8

Increase in O.N. = 1

Balanced equation is

$H_2SO_4 + 8HI \rightarrow H_2S + 4I_2 + 4H_2O$

$x = 8, y = 4, z = 4$

70. (c) : ΔH for $P \longrightarrow 2Q$ is obtained using Hess's law, by adding eqn. (i), eqn. (ii) and 2 × eqn. (iii); $\Delta H = x + y + 2z$.

71. (b) : In N_2O_4 dimer, N–N bond is formed by pairing of odd electrons on each nitrogen atom in NO_2 and all four N–O bonds become equivalent.

72. (c) : $\underset{(A)}{Ca(OH)_2} + Ca(HCO_3)_2 \longrightarrow \underset{\text{(Clark's method)}}{2CaCO_3\downarrow + 2H_2O}$

$\underset{(A)}{Ca(OH)_2} + Na_2CO_3 \longrightarrow CaCO_3\downarrow + \underset{\text{Caustic soda}}{2NaOH}$

$\underset{(A)}{Ca(OH)_2} + CO_2 \longrightarrow \underset{\text{Calcium carbonate (cloudy)}}{CaCO_3} + H_2O$

73. (c) : (I) contains 1° and 3° carbon atoms, (II) contains 2° and 3° carbon atoms and (III) contains only 2° carbon atoms. Hence, numbers of monochlorination products obtained from them are 2, 2 and 1.

74. (b) **75. (b)** **76. (b)**

77. (d) : $\underset{\text{Low pH}}{H_3\overset{+}{N}CH(R)COOH} \underset{H^+}{\overset{OH^-}{\rightleftharpoons}} \underset{\text{Intermediate pH}}{H_3\overset{+}{N}CH(R)COO^-} \underset{OH^-}{\overset{H^+}{\rightleftharpoons}} \underset{\text{High pH}}{H_2NCH(R)COO^-}$

$$K_1 = \frac{[H_3\overset{+}{N}CHRCOO^-][H^+]}{[H_3\overset{+}{N}CHRCOOH]}\ ;\ K_2 = \frac{[H_2NCHRCOO^-][H^+]}{[H_3\overset{+}{N}CHRCOO^-]}$$

$$\text{Thus, } K_1K_2 = \frac{[H_2NCHRCOO^-][H^+]^2}{[H_3\overset{+}{N}CHRCOOH]}$$

At the isoelectric point,

$[H_2NCHRCOO^-] = [H_3N^+CHRCOOH]$

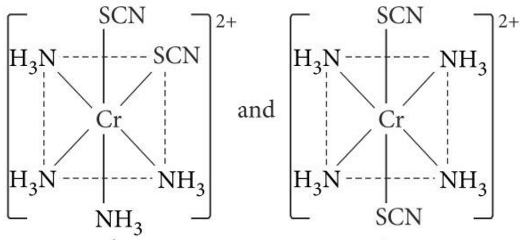
$K_1K_2 = [H^+]^2$; $2\log[H^+] = \log K_1 + \log K_2$

$-2\log[H^+] = -\log K_1 - \log K_2$

$2pH = pK_1 + pK_2$

or $pH = (pK_1 + pK_2)/2$

78. (d) : $[Cr(SCN)_2(NH_3)_4]^{2+}$ shows geometrical and linkage isomerism.



cis *trans*

$[Cr(SCN)_2(NH_3)_4]^{2+}$ and $[Cr(NCS)_2(NH_3)_4]^{2+}$ are linkage isomers. *cis*- and *trans*-forms are possible for both linkage isomers.

79. (a)

80. (c) : $M_2SO_4 \rightleftharpoons 2M^+ + SO_4^{2-}$

$K_{sp} = [M^+]^2[SO_4^{2-}] = (2s)^2(s) = 4s^3$

or $s = \left(\dfrac{1.2\times10^{-5}}{4}\right)^{1/3} = 1.44\times10^{-2}$

$\therefore$ Concentration of M^+ ions $= 2s = 2.88 \times 10^{-2}$ M

ANSWER KEYS

81. (d)	**82.** (b)	**83.** (c)	**84.** (a)	**85.** (a)
86. (b)	**87.** (b)	**88.** (d)	**89.** (a)	**90.** (b)
91. (b)	**92.** (a)	**93.** (d)	**94.** (a)	**95.** (d)
96. (a)	**97.** (c)	**98.** (d)	**99.** (d)	**100.** (b)
101. (c)	**102.** (d)	**103.** (d)	**104.** (b)	**105.** (b)
106. (a)	**107.** (d)	**108.** (a)	**109.** (b)	**110.** (a)
111. (a)	**112.** (d)	**113.** (d)	**114.** (c)	**115.** (c)
116. (b)	**117.** (d)	**118.** (c)	**119.** (b)	**120.** (a)
121. (c)	**122.** (b)	**123.** (a)	**124.** (b)	**125.** (d)
126. (a)	**127.** (a)	**128.** (b)	**129.** (c)	**130.** (a)
131. (b)	**132.** (b)	**133.** (c)	**134.** (a)	**135.** (c)
136. (c)	**137.** (a)	**138.** (a)	**139.** (d)	**140.** (c)
141. (d)	**142.** (a)	**143.** (b)	**144.** (a)	**145.** (c)
146. (c)	**147.** (c)	**148.** (c)	**149.** (a)	**150.** (c)

MPP CLASS XI ANSWER KEY

1. (c)	**2.** (a)	**3.** (c)	**4.** (d)	**5.** (a)
6. (a)	**7.** (d)	**8.** (a)	**9.** (a)	**10.** (d)
11. (b)	**12.** (b)	**13.** (c)	**14.** (c)	**15.** (c)
16. (d)	**17.** (b)	**18.** (c)	**19.** (c)	**20.** (a,c)
21. (c,d)	**22.** (a,d)	**23.** (b,c,d)	**24.** (3)	**25.** (8)
26. (4)	**27.** (a)	**28.** (b)	**29.** (d)	**30.** (b)

MPP MONTHLY Practice Paper

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **Time Taken : 60 min**

NEET / AIIMS

Only One Option Correct Type

1. Two identical containers A and B have frictionless pistons. They contain the same volume of an ideal gas at the same temperature. The mass of the gas in A is m_A and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to double the initial volume. The change in the pressure in A and B, respectively, is ΔP and $1.5\ \Delta P$. Then

(a) $4m_A = 9m_B$ (b) $2m_A = 3m_B$
(c) $3m_A = 2m_B$ (d) $9m_A = 4m_B$

2. The maximum height reached by projectile is 4 m. The horizontal range is 12 m. The velocity of projection in m s^{-1} is (g is acceleration due to gravity)

(a) $5\sqrt{g/2}$ (b) $3\sqrt{g/2}$
(c) $\frac{1}{3}\sqrt{g/2}$ (d) $\frac{1}{5}\sqrt{g/2}$

3. A bucket full of hot water cools from 75 °C to 70 °C in time T_1, from 70 °C to 65 °C in time T_2 and from 65 °C to 60 °C in time T_3, then

(a) $T_1 = T_2 = T_3$ (b) $T_1 > T_2 > T_3$
(c) $T_1 < T_2 < T_3$ (d) $T_1 > T_2 < T_3$

4. An observer standing on a railway crossing receives frequencies 2.2 kHz and 1.8 kHz when the train approaches and recedes from the observer. Find the velocity of the train (speed of sound in air is 300 m s^{-1}).

(a) 10 m s^{-1} (b) 20 m s^{-1}
(c) 25 m s^{-1} (d) 30 m s^{-1}

5. The velocity of a body falling freely under gravity varies as $g^a h^b$, where g is the acceleration due to gravity and h is the height. The value of a and b respectively are

(a) $\frac{1}{2}, \frac{1}{2}$ (b) $-\frac{1}{2}, -\frac{1}{2}$
(c) $-\frac{1}{2}, \frac{1}{2}$ (d) $\frac{1}{2}, -\frac{1}{2}$

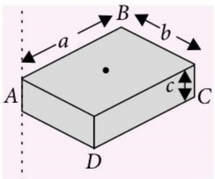
6. A cubical block of wood 10 cm along each side floats at the interface between an oil and water with its lowest surface 2 cm below the interface. If the heights of oil and water columns are 10 cm each and $\rho_{oil} = 0.8$ g cm^{-3}, find the mass of the block.

(a) 840 g (b) 940 g (c) 1040 g (d) 1500 g

7. A block is lying on the horizontal frictionless surface. One end of a uniform rope is fixed to the block which is pulled in the horizontal direction by applying a force F at the other end. If the mass of the rope is half the mass of the block, the tension in the middle of the rope will be

(a) F (b) $2F/3$ (c) $3F/5$ (d) $5F/6$

8. Figure shows a uniform solid block of mass M and edge lengths a, b and c. Its moment of inertia about an axis through one edge and perpendicular (as shown) to the large face of the block is



(a) $\frac{M}{3}(a^2+b^2)$ (b) $\frac{M}{4}(a^2+b^2)$
(c) $\frac{7M}{12}(a^2+b^2)$ (d) $\frac{M}{12}(a^2+b^2)$

9. What should be the lengths of steel and copper rods respectively so that the length of steel rod is 5 cm longer than copper rod at all temperatures? [α for copper = 1.7×10^{-5} °C^{-1} and α for steel = 1.1×10^{-5} °C^{-1}].
(a) 14.17 cm, 9.17 cm (b) 19 cm, 14 cm
(c) 17 cm, 12 cm (d) 9.17 cm, 4.17 cm

10. Four moles of hydrogen, 2 moles of helium and 1 mole of water vapour form an ideal gas mixture. What is the molar specific heat at constant pressure of mixture?
(a) $\frac{16}{7}R$ (b) $\frac{7R}{16}$ (c) R (d) $\frac{23}{7}R$

11. A stone is dropped into a well and its splash is heard after an interval of 1.45 s. Find the depth of top surface of water in the well. Given that the velocity of sound in air at room temperature is 332 m s^{-1}.
(a) 5 m (b) 11 m (c) 20 m (d) 30 m

12. A mass M is lowered with the help of a string by a distance h at a constant acceleration $g/2$. The work done by the string will be
(a) $\frac{Mgh}{2}$ (b) $-\frac{Mgh}{2}$
(c) $\frac{3Mgh}{2}$ (d) $-\frac{3Mgh}{2}$

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** If the earth suddenly stops rotating about its axis, then the acceleration due to gravity will become the same at all the places.
Reason : The value of acceleration due to gravity is independent of rotation of the earth.

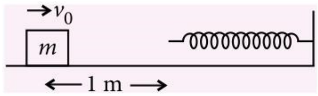
14. **Assertion :** The force of friction is dependent on normal reaction and the ratio of force of friction and normal reaction cannot exceed unity.
Reason : The coefficient of friction can be greater than unity.

15. **Assertion :** The time of flight of a body becomes n time the original value if its speed is made n time.
Reason : The range of the projectile becomes n times when speed becomes n times.

JEE MAIN / JEE ADVANCED

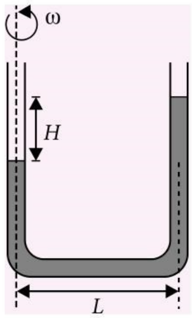
Only One Option Correct Type

16. A block of mass m = 2 kg is moving with velocity v_0 towards a massless unstretched spring of force constant k = 10 N m^{-1}. Coefficient of friction between the block and the ground is $\mu = \frac{1}{5}$.



Find maximum value of v_0, so that after pressing the spring, the block does not return back but stops there permanently.
(a) $\sqrt{12}$ m s^{-1} (b) $\sqrt{4.2}$ m s^{-1}
(c) $\sqrt{10}$ m s^{-1} (d) $\sqrt{6.4}$ m s^{-1}

17. A U-shaped tube contains a liquid of density ρ and it is rotated about the left dotted line as shown in the figure. Find the difference in the levels of the liquid column.



(a) $\frac{\omega^2 L^2}{2\sqrt{2}g}$
(b) $\frac{\omega^2 L^2}{2g}$
(c) $\frac{2\omega^2 L^2}{g}$
(d) $\frac{2\sqrt{2}\,\omega^2 L^2}{g}$

18. The molar heat capacity C for an ideal gas going through a process is given by $C = \frac{a}{T}$, where a is a constant. If $\gamma = \frac{C_P}{C_V}$, the work done by one mole of gas during heating from T_0 to $\eta\, T_0$ will be
(a) $a \ln(\eta)$
(b) $\frac{1}{a \ln(\eta)}$
(c) $a \ln(\eta) - \left(\frac{\eta - 1}{\gamma - 1}\right)RT_0$
(d) $a \ln(\eta) - (\gamma - 1)\, RT_0$

19. A particle performs SHM in a straight line. In the first second, starting from rest, it travels a distance a and in the next second it travels a distance b in the same direction. The amplitude of the SHM is

(a) $a - b$ (b) $\frac{2a-b}{3}$

(c) $\frac{2a^2}{3a-b}$ (d) None of these

More than One Options Correct Type

20. A driver in a stationary car blows a horn which produces sound waves of frequency 1000 Hz normally towards a reflecting wall. The sound reflected from the wall approaches the car with a speed of 3.3 m s^{-1}.

(a) The frequency of sound reflected from wall and heard by the driver is 1020 Hz.

(b) The frequency of sound reflected from wall and heard by the driver is 980 Hz.

(c) The percentage increase in frequency of sound after reflection from wall is 2%.

(d) The percentage decrease in frequency of sound after reflection from wall is 2%.

21. Two cities A and B are connected by a regular bus service with buses plying in either direction every T seconds. The speed of each bus is uniform and equal to v_b. A cyclist cycles from A to B with a uniform speed of v_c. A bus goes past the cyclist in T_1 second in the direction A to B and every T_2 second in the direction B to A. Then

(a) $T_1 = \frac{v_b T}{v_b + v_c}$ (b) $T_2 = \frac{v_b T}{v_b - v_c}$

(c) $T_1 = \frac{v_b T}{v_b - v_c}$ (d) $T_2 = \frac{v_b T}{v_b + v_c}$

22. A double star is a system of two stars of masses m and $2m$, rotating about their centre of mass only under their mutual gravitational attraction. If r is the separation between these two stars then their time period of rotation about their centre of mass will be proportional to

(a) $r^{\frac{3}{2}}$ (b) r (c) $m^{\frac{1}{2}}$ (d) $m^{-\frac{1}{2}}$

23. 5 kg of steam at 100 °C is mixed with 10 kg of ice at 0 °C. Then (Given s_{water} = 1 cal g^{-1} °C, L_F = 80 cal g^{-1}, L_V = 540 cal g^{-1})

(a) equilibrium temperature of mixture is 160 °C

(b) equilibrium temperature of mixture is 100 °C

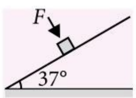
(c) at equilibrium, mixture contains $13\frac{1}{3}$ kg of water

(d) at equilibrium, mixture contains $1\frac{2}{3}$ kg of steam

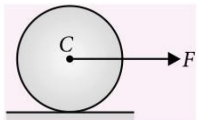
Integer Answer Type

24. The value of $\gamma = C_P/C_V$ is 4/3 for an adiabatic process of an ideal gas for which internal energy $U = K + n\,PV$. Find the value of n (K is a constant).

25. A block of mass m = 2 kg is resting on a rough inclined plane of inclination 37° as shown in figure. The coefficient of friction between the block and the plane is μ = 0.5. What minimum force F (in N) should be applied perpendicular to the plane on the block so, that the block does not slip on the plane? $\left[\sin 37° = \frac{3}{5}\right]$

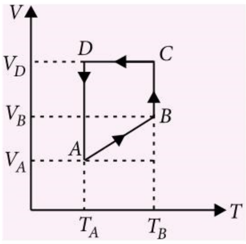


26. A horizontal force F = 14 N acts at the centre of mass of a sphere of mass m = 1 kg. If the sphere rolls without sliding, find the frictional force (in N).



Comprehension Type

A monatomic ideal gas of two moles is taken through a cyclic process starting from A as shown in figure with $V_B/V_A = 2$. Temperature T_A at A is 27 °C



27. The temperature at B, T_B is

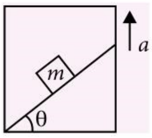
(a) 600 K (b) 450 K
(c) 400 K (d) 900 K

28. The work done during the process $A \rightarrow B$ is

(a) 1200 R (b) 1500 R
(c) 1600 R (d) 1000 R

Matrix Match Type

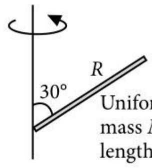
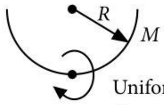
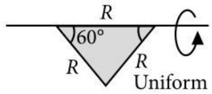
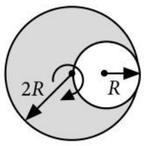
29. A block of mass m is stationary with respect to a rough wedge as shown in figure. Starting from rest in time t, work done by various force is given in the columns. Match the column I with column II. (g = 10 m s^{-2}, m = 1 kg, a = 2 m s^{-2}, t = 4 s).



	Column I		Column II
(A)	By gravity	(P)	144 J
(B)	By normal reaction	(Q)	32 J
(C)	By friction	(R)	160 J
(D)	By all the forces	(S)	48 J

	A	B	C	D
(a)	P	Q	S	R
(b)	S	Q	P	R
(c)	P	Q	R	S
(d)	R	P	S	Q

30. Column I gives some systems whose moment of inertia are listed in column II about the shown axis. Match column I with column II.

	Column I		Column II
(A)	 Uniform rod of mass M and length R	(P)	$\frac{8MR^2}{11}$
(B)	 Uniform semicircular ring of mass M. Axis is perpendicular to its plane.	(Q)	$\frac{MR^2}{12}$
(C)	 Uniform triangular plate of mass M	(R)	$\frac{13MR^2}{8}$
(D)	 Uniform disk of initial mass M from which a circular portion of radius R is then removed. Axis is perpendicular to its plane.	(S)	$\frac{MR^2}{8}$

	A	B	C	D
(a)	Q	R	P	S
(b)	Q	P	S	R
(c)	S	P	R	Q
(d)	R	S	Q	P

◆◆

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted ……
No. of questions correct ……
Marks scored in percentage ……

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

CBSE BOARD PRACTICE PAPER 2018

Exam on 7th March

Time Allowed : 3 hours
Maximum Marks : 70

GENERAL INSTRUCTIONS

(i) All questions are compulsory.
(ii) Q. no. 1 to 5 are very short answer questions and carry 1 mark each.
(iii) Q. no. 6 to 10 are short answer questions and carry 2 marks each.
(iv) Q. no. 11 to 22 are also short answer questions and carry 3 marks each.
(v) Q. no. 23 is a value based question and carry 4 marks.
(vi) Q. no. 24 to 26 are long answer questions and carry 5 marks each.
(vii) Use log tables if necessary, use of calculators is not allowed.

SECTION - A

1. What is the work done in moving a test charge q through a distance of 1 cm along the equatorial axis of an electric dipole?

2. A car battery is of 12 V. 8 simple cells connected in series can give 12 V; but such cells are not used in starting a car; why?

3. A thin prism of angle 60° gives a minimum deviation of 30°. What is the refractive index of the material of the prism?

4. Here three lenses have been given. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope?

Lenses	Power (P)	Aperture (A)
L_1	3 D	8 cm
L_2	6 D	1 cm
L_3	10 D	1 cm

5. Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled, what happens to photoelectric current?

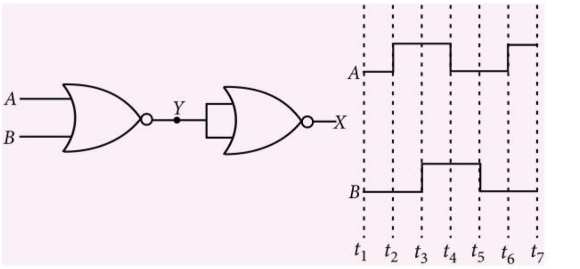
SECTION - B

6. A charged 30 μF capacitor is connected to a 27 mH inductor. What is the angular frequency of free oscillations of the circuit?

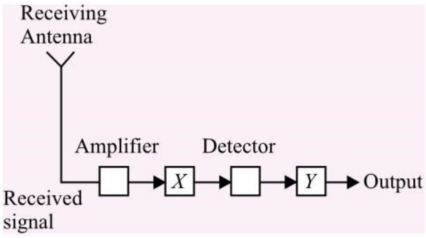
7. For an electromagnetic wave propagating along x-axis, an oscillating electric field along y-axis in free space has a frequency of 6.0×10^8 Hz and also an amplitude of $E_0 = 27\ \text{V m}^{-1}$. Write the equations for $\vec{E}$ and $\vec{B}$ of the given electromagnetic wave.

8. A convex lens of focal length 30 cm is placed coaxially with a convex mirror of radius of curvature 20 cm. The two are kept at 15 cm from each other. A point object lies 60 cm in front of the convex lens. Determine the nature and position of the image formed.

9. Draw the output waveform at X, using the given inputs A and B for the logic circuit shown here. Also, identify the logic operation performed by this circuit.



10. In the given block diagram of a receiver, identify the boxes labelled as X and Y and write their functions.



OR

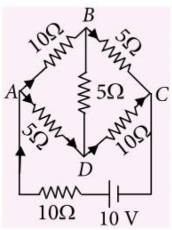
A transmitting antenna at the top of a tower has a height 32 m and the height of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in LOS mode? Given radius of earth is 6.4×10^6 m.

SECTION - C

11. n tiny drops, all of same size, are given equal charges. If the drops coalesce to form a single bigger drop, then what will be the new potential of the drop? What is the surface charge density of the bigger drop?

12. Using Gauss' law establish that the magnitude of electric field intensity, at a point, due to an infinite plane sheet, with uniform charge density σ is independent of the distance of the field point.

13. Determine the current in each branch of the network shown in figure.



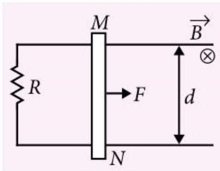
14. A short bar magnet placed with its axis at 30° with an external field of 600 G experiences a torque of 0.015 N m.

(a) What is the magnetic moment of the magnet?

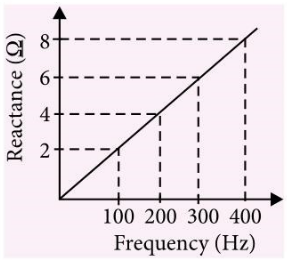
(b) What is the work done in moving it from its most stable to most unstable position?

(c) The bar magnet is replaced by a solenoid of cross-sectional area 10^{-4} m^2 and 1000 turns, but of the same magnetic moment. Determine the current flowing through the solenoid.

15. Two long parallel horizontal rails, distance d apart and each having a resistance λ per unit length, are joined at one end by a resistance R. A perfectly conducting rod MN of mass m is free to slide along the rails without friction as shown in figure. There is a uniform magnetic field of induction B normal to the plane of the paper and directed into the paper. A variable force F is applied to the rod MN such that as the rod moves, constant current flows through R. Find the velocity of the rod and the applied force F as a function of the distance x of the rod from R.



16. Figure shows how the reactance of an inductor varies with frequency.



(a) Calculate the value of the inductance of the inductor using the information given in the graph.

(b) If this inductor is connected in series to a resistor of 8 Ω, find what would be the impedance at 300 Hz?

17. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double slit experiment. What is the least distance from the central maximum where the bright fringes due to the both the wavelengths coincide? The distance between the slits is 2 mm and the distance between the plane of the slits and screen is 120 cm.

18. In a single slit diffraction experiment, when a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain why? State two points of difference between the interference pattern in Young's double slit experiment and diffraction pattern due to a single slit.

19. Radiations of frequency 10^{15} Hz are incident on two photosensitive surfaces A and B. Following observations are recorded :

Surface A : No photoemission takes place.

Surface B : Photoemission takes place but photo-electrons have zero energy.

Explain the above observations on the basis of Einstein's photoelectric equation. How will the observation with surface B change when wavelength of incident light is decreased ?

OR

Obtain the de Broglie wavelength associated with thermal neutrons at room temperature (27°C). Hence explain why a fast neutron beam needs to be thermalised with the environment before it can be used for neutron diffraction experiments.(mass of neutrons $m = 1{\cdot}675 \times 10^{-27}$ kg, Boltzmann constant $k = 1{\cdot}38 \times 10^{-23}\ \text{J K}^{-1}$)

20. Obtain an expression for the frequency of radiation emitted when a hydrogen atom de-excites from level n to level $(n - 1)$. For large n, show that this frequency equals the classical frequency of revolution of the electron in the orbit.

21. A 1000 MW fission reactor consumes half of its fuel in 5.00 years. How much $^{235}_{92}U$ did it contain initially? Assume that all the energy generated arises from the fission of $^{235}_{92}U$ and that this nuclide is consumed only by the fission process. The energy released per fission is 200 MeV.

22. Define the term modulation index for an AM wave. What would be the modulation index for an AM wave for which the maximum amplitude is a while the minimum amplitude is b?

SECTION - D

23. Shivansh was doing an experiment of comparison of emf using potentiometer in Physics lab. He observed that the galvanometer was showing one side deflection by touching at any point of potentiometer wire. His classmate 'Risha Mushir' who was also doing her experiment checked the circuit and suggested to increase the voltage of the battery eliminator from 2 V to 6 V connected in the standard calibrating circuit of the potentiometer. Shivansh did the same and was able to observe two side deflection along the length of potentiometer wire and could get null point with the help of galvanometer. He was thankful to 'Risha Mushir' and asked for the cause of the same.

(a) What are the values displayed by both Shivansh and Risha Mushir?

(b) State the reason why galvanometer showed same side deflection.

(c) Distinguish between emf and potential difference.

SECTION - E

24. Draw a neat and labelled diagram of a cyclotron. State the underlying principle and explain how a positively charged particle gets accelerated in this machine. Show mathematically that the cyclotron frequency does not depend upon the speed of the particle.

OR

State Biot-Savart law. Use it to obtain the magnetic field, at an axial point, distance z from the centre of a circular coil of radius a, carrying a current I. Hence, compare the magnitudes of the magnetic field of this coil at its centre and at an axial point for which $z = \sqrt{3}\,a$.

25. Derive the lens-maker's formula in case of a double convex lens. State the assumptions made and conventions of signs used.

OR

(a) Draw a labelled ray diagram of an astronomical telescope used in the normal adjustment position. Write the expression for its magnifying power.

(b) Write expression for magnifying power of astronomical telescope when final image is formed at least distance of distinct vision.

26. What is a p-n junction? Explain with the help of a diagram, how depletion layer is formed near the junction. Explain also what happens to this layer when the junction is (i) forward biased and (ii) reverse biased.

OR

Give the symbols of npn and pnp transistor. Show the biasing of an npn transistor and explain its action.

SOLUTIONS

1. Work done is zero because potential at any point on the equatorial line of an electric dipole is zero. Hence, work done,

$$W = q(V_2 - V_1) = 0$$

2. The internal resistance of simple cells is high; therefore the series combination of simple cells does not give enough current required to start a car.

3. $$\mu = \frac{\sin\dfrac{A+\delta_m}{2}}{\sin\dfrac{A}{2}} = \frac{\sin\left(\dfrac{60°+30°}{2}\right)}{\sin\left(\dfrac{60°}{2}\right)} = \frac{\sin 45°}{\sin 30°}$$

$$= \frac{1/\sqrt{2}}{1/2} = \sqrt{2} = 1.41$$

4. Since the aperture of lens L_1 is largest, it is used as objective for a telescope. The lens L_3 is used as eyepiece since its focal length is smaller.

5. If the frequency is halved, the frequency of incident light will become $\frac{1.5}{2}$ = 0.75 times (*i.e.*, less than 1) the threshold frequency. Hence, photoelectric current will be zero.

6. For the free oscillations, the angular frequency should be resonant frequency.

Resonant angular frequency of oscillation of the circuit,

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{27\times10^{-3}\times30\times10^{-6}}} = \frac{10^4}{9} = 1.1\times10^3 \text{rad s}^{-1}$$

7. As per question, direction of propagation of electromagnetic wave is along x-axis.

$E_0 = 27$ V m^{-1} and $\upsilon = 6.0 \times 10^8$ Hz

$\therefore$ $\omega = 2\pi\upsilon = 2\pi \times 6.0 \times 10^8 = 1.2\pi \times 10^9$ rad s^{-1}

$$\therefore \quad k = \frac{\omega}{c} = \frac{1.2\pi\times10^9}{3\times10^8} = 4\pi \text{ rad m}^{-1}$$

$\therefore$ Equation for electric field, $\vec{E} = E_0 \sin(\omega t - kx)\hat{j}$

$\vec{E} = 27 \sin[1.2\,\pi \times 10^9\, t - 4\pi\, x]\,\hat{j}$ V m^{-1}

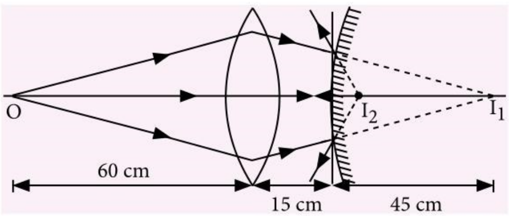
Further, $B_0 = \frac{E_0}{c} = \frac{27}{3\times10^8} = 9\times10^{-8}$ T

Moreover, magnetic field should be along the z-axis.

Hence, $\vec{B} = B_0 \sin(\omega t - kx)\,\hat{k}$

$\vec{B} = 9 \times 10^{-8} \sin[1.2\,\pi \times 10^9\, t - 4\pi\, x]\,\hat{k}$ T

8. O is at $2f$ of lens, so it will form image at $2f$ on other side, *i.e.*, 60 cm from lens. Hence, position of virtual object from mirror is at (60–15) cm = 45 cm behind the mirror. The ray diagram briefing the image formation is shown here.



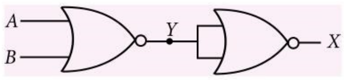
For mirror, R = 20 cm, f = +10 cm, u = +45 cm, v = ?

As, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{45} = \frac{1}{10}$

$\therefore \quad v = +\frac{90}{7}$ cm (Behind the mirror)

$\therefore$ An virtual image is formed at a distance $\frac{90}{7}$ cm behind the mirror.

9.

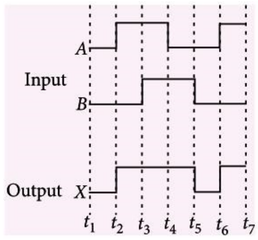


Boolean expression of this combination is,

$Y = \overline{A+B}$ and $X = \overline{Y} = \overline{\overline{A+B}} = A+B$

Therefore, the given logic circuit acts as OR gate. Hence, output is high when both or one of them is high.

Accordingly the waveform of output is shown in figure.



10. X = Intermediate frequency (IF) stage

Y = Amplifier/Power amplifier

IF Stage : IF stage changes the carrier frequency to a lower frequency.

Amplifier: Increases the strength of signals.

OR

For LOS mode,

$$d_m = \sqrt{2h_T R} + \sqrt{2h_R R}$$

$$= \sqrt{2\times64\times10^5\times32} + \sqrt{2\times64\times10^5\times50}$$

$$= 64\times10^2\times\sqrt{10} + 8\times10^3\sqrt{10} = 144\times10^2\times\sqrt{10} \text{ m}$$

$d_m = 45.5$ km

11. Let each drop be having a radius r and charge q. Then, potential at the surface of each drop,

$$V = \frac{q}{4\pi\varepsilon_0 r}$$

and surface charge density, $\sigma = \frac{q}{4\pi r^2}$

When n drops coalesce to form a single bigger drop of radius R, total volume remains unchanged.

Hence, $\frac{4}{3}\pi R^3 = n\times\frac{4}{3}\pi r^3 \Rightarrow R = (n)^{1/3} r$

and total charge on the bigger drop, $Q = nq$

$\therefore$ Potential of bigger drop,

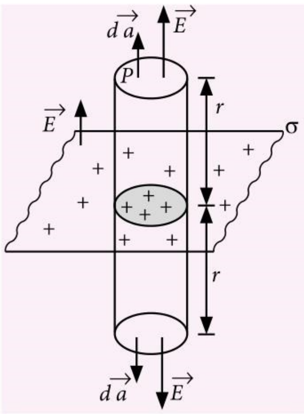
$$V' = \frac{Q}{4\pi\varepsilon_0 R} = \frac{nq}{4\pi\varepsilon_0 (n)^{1/3} r} = (n)^{2/3} V$$

and new surface charge density,

$$\sigma' = \frac{Q}{4\pi R^2} = \frac{nq}{4\pi n^{2/3} r^2} = (n)^{1/3}\sigma$$

12. According to Gauss' theorem total electric flux through a closed surface is $\frac{1}{\varepsilon_0}$ times the net charge enclosed by the surface, *i.e.*,

$$\phi_E = \oint_A \vec{E}.d\vec{a} = \frac{q}{\varepsilon_0}$$



Consider a thin infinite plane sheet of charge with uniform surface charge density σ. To calculate electric field at a point (P) at distant r from the sheet, we imaging a symmetrical Gaussian surface in such a way that the point lies on it.

Here we assume a cylinder of cross-sectional area A and length $2r$ with its axis perpendicular to the sheet.

Flux through the curved surface of the cylinder (ϕ_1) :

As electric lines are parallel to the curved surface, flux through it is zero.

$$\phi_1 = \int \vec{E}.d\vec{a} = 0 \qquad (\because\ \theta = 90°)$$

Flux through the plane faces of the cylinder (ϕ_2):

$$\phi_2 = 2\int \vec{E}.d\vec{s} = 2EA \qquad (\because\ \theta = 0°)$$

Total flux through the cylindrical Gaussian surface is

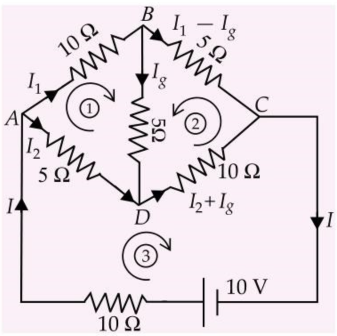
$\phi = \phi_1 + \phi_2 = 2EA$.

Total charge enclosed by the surface $q = \sigma A$

According to Gauss' theorem, $\phi = \dfrac{q}{\varepsilon_0}$

i.e., $2EA = \dfrac{\sigma A}{\varepsilon_0}$ or $E = \dfrac{\sigma}{2\varepsilon_0}$ = constant

13. Let us first distribute the current in different branches. Now, equations for different loops using Kirchhoff's second law,



Loop 1

$10I_1 + 5I_g - 5I_2 = 0$ or $2I_1 + I_g - I_2 = 0$ ...(i)

Loop 2

$5I_g + 10(I_2 + I_g) - 5(I_1 - I_g) = 0$

or $2I_2 + 4I_g - I_1 = 0$ ...(ii)

Loop 3

$5I_2 + 10(I_2 + I_g) + 10I = 10$ or $15I_2 + 10I_g + 10I = 10$

or $3I_2 + 2I_g + 2I = 2$ ...(iii)

Solving equations (i) and (ii),

$I_1 = -2I_g$ ...(iv)

Equations (i) and (iv)

$I_2 = -3I_g$ ...(v)

Now using the equation (v) in equation (iii),

$-3[3I_g] + 2I_g + 2I = 2$ or $2I - 7I_g = 2$ ...(vi)

Using Kirchhoff's law, $I = I_1 + I_2$

$I = -5I_g$ (using (iv) and (v))

So, equation (vi),

$2[-5I_g] - 7I_g = 2$ or $-17I_g = 2$

So, $I_g = \dfrac{-2}{17}$ A and $I = \dfrac{+10}{17}$ A

Also $I_1 = \dfrac{4}{17}$ A, $I_2 = \dfrac{6}{17}$ A

$I_1 - I_g = \dfrac{6}{17}$ A, $I_2 + I_g = \dfrac{4}{17}$ A

14. (a) Torque experienced by the bar magnet

$\tau = MB \sin\theta$

$0.015 = M(600 \times 10^{-4}) \sin 30°$

$M = 0.5\ \text{A m}^2$

(b) Most stable position when $\theta_i = 0°$

and most unstable when $\theta_f = 180°$

Work done, $W = MB[\cos\theta_i - \cos\theta_f]$

$W = 0.5 \times 600 \times 10^{-4} [\cos 0° - \cos 180°]$

$W = 0.06$ J

(c) A solenoid provides dipole moment

$M = NIA$

$0.5 = 1000 \times 10^{-4} I$

$I = 5$ A

15. Let the distance from R to MN be x. Then the area of the loop between MN and resistance R is xd and the magnetic flux linked with the loop is $B\,x\,d$. As the rod moves, the emf induced in the loop is given by

$$|\varepsilon| = \frac{d}{dt}(B\,x\,d) = B\,d\frac{dx}{dt} = B\,v\,d$$

where v is the velocity of MN. The total resistance of the loop is $R + 2\lambda x$. The current in the loop is given by

$$I = \frac{|\varepsilon|}{R+2\lambda x} = \frac{Bvd}{R+2\lambda x}$$

(i) Force acting on the rod,

$$F = IBd = \frac{B^2d^2}{R+2\lambda x}v$$

$$\therefore\ m\frac{dv}{dt} = \frac{B^2d^2}{R+2\lambda x}\cdot\frac{dx}{dt} \quad \text{or} \quad dv = \frac{B^2d^2}{m}\cdot\frac{dx}{R+2\lambda x}$$

On integrating both sides, we get

$$v = \frac{B^2d^2}{2\lambda m}\ln\left(\frac{R+2\lambda x}{R}\right)$$

$$F=\frac{B^2d^2}{R+2\lambda x}\cdot\frac{B^2d^2}{2\lambda m}\ln\left(\frac{R+2\lambda x}{R}\right)$$
$$=\frac{B^4d^4}{(2\lambda m)(R+2\lambda x)}\ln\left(\frac{R+2\lambda x}{R}\right)$$

16. $X_L=2\pi\upsilon L,\ L=\frac{X_L}{2\pi\upsilon}=\frac{1}{2\pi}\left(\frac{X_L}{\upsilon}\right)$

From the graph, $\text{Slope}=\frac{8-4}{400-200}=\frac{4}{200}=\frac{1}{50}$

(a) $L=\frac{1}{2\pi}\times(\text{slope})=\frac{1}{2\pi}\left(\frac{1}{50}\right)=\frac{1}{100}\text{H}$

(b) At 300 Hz, $X_L=6\ \Omega$

Impedance, $Z=\sqrt{R^2+X_L^2}=\sqrt{8^2+6^2}=10\ \Omega$

17. For least distance of coincidence of fringes, there must be a difference of 1 in order of λ_1 and λ_2.

As $\lambda_1>\lambda_2,\ n_1<n_2$

If $n_1=n,\ n_2=n+1$

$\therefore\ (y_n)_{\lambda_1}=(y_{n+1})_{\lambda_2}\Rightarrow\frac{nD\lambda_1}{d}=\frac{(n+1)D\lambda_2}{d}$

$\Rightarrow\ n\lambda_1=(n+1)\lambda_2$

$\Rightarrow\ n=\frac{\lambda_2}{\lambda_1-\lambda_2}=\frac{520\text{ nm}}{(650-520)\text{ nm}}$ or $n=\frac{520}{130}=4$

Here $D=120$ cm $=1.20$ m, $d=2$ mm $=2\times10^{-3}$ m

$\therefore$ Least distance,

$$y_{min}=\frac{nD\lambda_1}{d}=\frac{4\times1.2\times650\times10^{-9}}{2\times10^{-3}}\text{ m}$$
$$=1.56\times10^{-3}\text{ m}=1.56\text{ mm}$$

18. When a tiny circular obstacle is placed in the path of light from a distant source a bright spot is seen at the centre of the shadow of the obstacle because of the constructive interference of diffracted rays of light by the circular obstacle.

Interference pattern (By Young's double slit experiment.)	Diffraction pattern (Due to a single slit.)
(i) All the bright and dark fringes are of same width.	(i) Central bright fringe is twice the width of any other secondary bright or dark fringe.
(ii) All the bright fringes are of same intensity.	(ii) Intensity of central bright fringe is maximum and it decreases with increase in the order of secondary bright fringes.

19. Einstein's photoelectric equation is

$h\upsilon=W+E_k\Rightarrow E_k=h\upsilon-W$ or $E_k=h\upsilon-h\upsilon_0$ ...(i)

where W is work function of metal, υ is frequency of incident light and υ_0 is threshold frequency.

Surface A : As no photoemission takes place; energy of incident photon is less than the work function.

Surface B : As photoemission takes place with zero kinetic energy of photolectrons (*i.e.*, $E_k=0$), then equation (i) gives $W=h\upsilon$ or $\upsilon_0=\upsilon$.

i.e., energy of incident photon is equal to work function. When wavelength of incident light is decreased, the energy of incident photon becomes more than the work function, so photoelectrons emitted will have finite kinetic energy given by

$$E_k=\frac{hc}{\lambda}-W=\frac{hc}{\lambda}-h\upsilon_o\qquad(\upsilon_0=10^{15}\text{ Hz})$$

OR

de Broglie wavelength associated with thermal neutrons,

$$\lambda=\frac{h}{\sqrt{3m\,kT}}$$

Here mass of neutron, $m=1{\cdot}675\times10^{-27}$ kg

$T=27°\text{C}=(27+273)\text{ K}=300\text{ K}$

$$\therefore\ \lambda=\frac{6\cdot63\times10^{-34}}{\sqrt{(3\times1\cdot675\times10^{-27}\times1\cdot38\times10^{-23}\times300)}}$$
$$=\frac{6\cdot63\times10^{-34}}{\sqrt{(3\times1\cdot675\times1\cdot38\times3)\times10^{-48}}}=\frac{6\cdot63\times10^{-10}}{4\cdot56}$$
$$=1{\cdot}45\times10^{-10}\text{ m}=1{\cdot}45\text{ Å}$$

This is comparable with interatomic spacing in a crystal. Thus thermal neutrons may be diffracted by crystals and hence are a suitable probe for diffraction experiments. High energy neutron beam has smaller wavelength and has larger probability of passing through the crystal spacing without suffering any diffraction. That is why a fast neutron beam needs to be thermalised with the environment before it can be used for neutron diffraction experiments.

MPP CLASS XII ANSWER KEY

1. (b)	**2.** (b)	**3.** (a)	**4.** (b)	**5.** (b)
6. (a)	**7.** (b)	**8.** (c)	**9.** (c)	**10.** (c)
11. (b)	**12.** (b)	**13.** (d)	**14.** (d)	**15.** (b)
16. (b)	**17.** (b)	**18.** (b)	**19.** (c)	**20.** (a,b,c)
21. (b,d)	**22.** (b, d)	**23.** (a,c,d)	**24.** (9)	**25.** (2)
26. (3)	**27.** (c)	**28.** (c)	**29.** (d)	**30.** (a)

20. Let us first find the frequency of revolution of electron in the orbit classically.

In Bohr's model velocity of electron in n^{th} orbit is

$v = \frac{nh}{2\pi mr}$, where radius $r = \frac{n^2h^2\varepsilon_0}{\pi me^2}$

Thus orbital frequency of electron in n^{th} orbit is

$$\upsilon = \frac{v}{2\pi r} = \frac{nh/2\pi mr}{2\pi r} = \frac{nh}{4\pi^2 mr^2} = \frac{nh}{4\pi^2 m}\left[\frac{\pi me^2}{n^2h^2\varepsilon_0}\right]^2$$

or $\upsilon = \frac{me^4}{4n^3h^3\varepsilon_0{}^2}$ ...(i)

The frequency of radiation emitted when a hydrogen atom de-excites from level n to level $(n - 1)$,

$$\upsilon = \frac{me^4}{8\varepsilon_0^2h^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] = \frac{me^4}{8\varepsilon_0^2h^3}\left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right]$$

or $\upsilon = \frac{me^4}{8\varepsilon_0^2h^3}\left[\frac{2n-1}{n^2(n-1)^2}\right]$

For large n, $2n - 1 \approx 2n$ and $n - 1 \approx n$, frequency,

$\upsilon = \frac{me^4}{8\varepsilon_0^2h^3}\left[\frac{2n}{n^4}\right] = \frac{me^4}{4n^3h^3\varepsilon_0{}^2}$ ...(ii)

Equations (i) and (ii) are equal, hence for large value of n, the classical frequency of revolution of electron in n^{th} orbit is same as frequency of radiation when electron de-excite from level n to $(n - 1)$.

21. Power of reactor = 1000 MW = 10^9 W= 10^9 J s^{-1}

Energy generated by reactor in 5 years

= $5 \times 365 \times 24 \times 60 \times 60 \times 10^9$ J

Energy generated per fission = 200 MeV

= $200 \times 1.6 \times 10^{-13}$ J

Number of fission taking place or number of U^{235} nuclei required $= \frac{5\times365\times24\times60\times60\times10^9}{200\times1.6\times10^{-13}}$ = 49.275×10^{26}

Mass of 6.023×10^{23} nuclei of U = 235 g = 235×10^{-3} kg

Mass of 49.275×10^{26} nuclei of U

$= \frac{235\times10^{-3}}{6.0203\times10^{23}}\times49.275\times10^{26} \simeq 1923$ kg

$\frac{1}{2}$ of total fuel = 1923 kg

Total fuel = 3846 kg

22. (a) In AM, modulation index is the ratio of amplitude of modulating signal to the amplitude of carrier wave $\mu = \frac{A_m}{A_c}$

(b) Since AM wave is given by

$C_m(t) = (A_c + A_m \sin \omega_m t) \sin \omega_m t$

So, maximum amplitude is $A_c + A_m = a$

and minimum amplitude is $A_c - A_m = b$

Adding them, we get $A_c = \frac{a+b}{2}$

So, modulation index $\mu = \frac{A_m}{A_c} = \frac{a-b}{a+b}$

23. (a) Sharing of knowledge, caring for each other and open for discussion and learning from each other.

(b) This happens when the emf of the driving cell is not greater than the emf of experimental cell or the positive ends of all cells are the connected to the same end of the wire.

(c) The maximum potential difference between terminals of a cell in an open circuit is called as emf and the potential difference between terminals when some current is drawn is called terminal potential or potential difference.

24. Refer to point 5, Page no. 173 (MTG Excel in Physics).

OR

Refer to point 3.1 (1, 3), Page no. 169 (MTG Excel in Physics).

25. Refer to 6.6 (1, 2), Page no. 374 (MTG Excel in Physics).

OR

Refer to point 2, Page no. 382 (MTG Excel in Physics).

26. Refer to point 9.3 (1, 2, 4, 5), Page no. 587 (MTG Excel in Physics).

OR

Refer to point 9.4 (1, 3, 4), Page no. 592 (MTG Excel in Physics).

◈◈

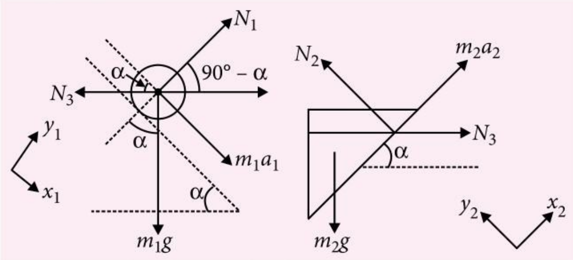
Solution Senders of Physics Musing

SET-55

1. Suhas Sheikh, Mumbai
2. Anita Dabbas, Uttar Pradesh
3. Vipul Gorai, West Bengal

Contd. from Page No. 26

7. Free body diagram of cylinder and wedge are shown in figure.



Equation of motion of cylinder,

$m_1g\sin\alpha - N_3\cos\alpha = m_1a_1$ ...(i)

Equation of motion of wedge;

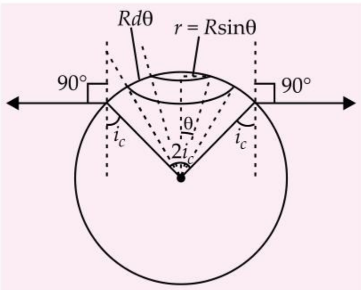
$N_3\cos\alpha - m_2g\sin\alpha = m_2a_2$ ...(ii)

Since $a_1 = a_2$ ...(iii)

On solving, equations (i), (ii) and (iii), we get

$$N_3 = \frac{2m_1m_2}{m_1 + m_2} g \tan\alpha$$

8. The light energy which escapes is combined within cone of apex angle $2i_c$, where i_c is critical angle for total internal reflection. Consider source of light is at the centre of sphere and surface area A of the sphere is inside the cone.



$\therefore$ Fraction of energy passing out $f = \dfrac{A}{4\pi R^2}$ ...(i)

Area of the differential ring of angular thickness $d\theta$ on the sphere is

$dA = 2\pi R\sin\theta(Rd\theta)$,

On integrating,, we get,

$$A = 2\pi R^2 \int_0^{i_c} \sin\theta d\theta = 2\pi R^2(1 - \cos i_c)$$

$$\frac{A}{2\pi R^2} = (1 - \cos i_c) \text{ or } \frac{2A}{4\pi R^2} = (1 - \cos i_c)$$

or $2f = (1 - \cos i_c)$ (using (i))

$$\therefore \quad f = \frac{(1 - \cos i_c)}{2}$$

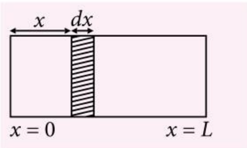
As $\cos i_c = \sqrt{1 - \sin^2 i_c}$

Since, $\sin i_c = \dfrac{1}{\mu}$ $\quad\therefore\quad \cos i_c = \sqrt{1 - \dfrac{1}{\mu^2}}$ ...(ii)

$$\therefore \quad f = \frac{1}{2}\left[1 - \sqrt{1 - \frac{1}{\mu^2}}\right] \quad \text{(using (ii))}$$

9. Consider an infinitesimal length dx of tube at a distance x from one end of capillary tube of cross-sectional area A.

$\therefore$ Volume of this section = Adx



Here, $T = T_0 + \left(\dfrac{T_L - T_0}{L}\right)x$

Volume of the capillary,

$V = AL$, is constant.

Applying ideal gas equation to this differential volume, we get

$$P(Adx) = dnRT = dnR\left[T_0 + \left(\frac{T_L - T_0}{L}\right)x\right]$$

$$\text{or} \quad \int_0^L \frac{dx}{\left[T_0 + \left(\frac{T_L - T_0}{L}\right)x\right]} = \int_0^n \frac{R}{PA} dn$$

$$\frac{L}{(T_L - T_0)} \ln\left[T_0 + \left(\frac{T_L - T_0}{L}\right)x\right]_0^L = \frac{nR}{PA}$$

Solving, we get

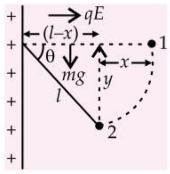
$$\frac{L}{(T_L - T_0)} \ln\left[T_0 + \left(\frac{T_L - T_0}{L}\right)x\right]_0^L = \frac{nR}{PA}$$

10. Using conservation of energy

ΔK.E. = ΔP.E.

$\Rightarrow \quad 0 = mgy - qEx$

$\Rightarrow \quad \dfrac{y}{x} = \dfrac{qE}{mg}$ ...(i)



From figure, $\sin\theta = \dfrac{y}{l}$

$\Rightarrow \quad y = l\sin\theta$

and $\cos\theta = \dfrac{l - x}{l} \Rightarrow \cos\theta = 1 - \dfrac{x}{l}$ or $x = l(1 - \cos\theta)$

$$\therefore \quad \frac{y}{x} = \frac{l\sin\theta}{l(1 - \cos\theta)} = \frac{2\sin(\theta/2)\cos(\theta/2)}{2\sin^2(\theta/2)} = \frac{1}{\tan(\theta/2)}$$

$$\tan\frac{\theta}{2} = \frac{x}{y} = \frac{mg}{qE} \quad \text{(Using eqn. (i))}$$

$$\theta = 2\tan^{-1}\left(\frac{mg}{qE}\right) = 2\tan^{-1}\left(\frac{2mg\varepsilon_0}{q\sigma}\right)$$

MPP MONTHLY Practice Paper

Class XII

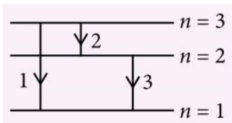
This specially designed column enables students to self analyse their extent of understanding of complete syllabus. Give yourself four marks for correct answer and deduct one mark for wrong answer.
Self check table given at the end will help you to check your readiness.

Total Marks : 120 **Time Taken : 60 min**

NEET / AIIMS

Only One Option Correct Type

1. Wavelengths of photons in transitions having serial numbers 1, 2, and 3 of a hydrogen like atom are λ_1, λ_2 and λ_3 respectively. Then, mark the correct option.



(a) $\lambda_1 = \lambda_2 + \lambda_3$ (b) $\lambda_1 = \dfrac{\lambda_3\lambda_2}{\lambda_3 + \lambda_2}$

(c) $\lambda_3 = \dfrac{\lambda_1 + \lambda_2}{\lambda_1\lambda_2}$ (d) $\lambda_2 = \lambda_1 - \lambda_3$

2. For an AC circuit, the voltage applied is $\varepsilon = \varepsilon_0 \sin \omega t$. The resulting current in the circuit is $I = I_0 \sin\left(\omega t - \dfrac{\pi}{2}\right)$. The power consumption in the circuit is given by

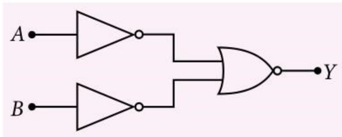
(a) $\dfrac{\varepsilon_0 I_0}{\sqrt{2}}$ (b) zero

(c) $\dfrac{\varepsilon_0 I_0}{2}$ (d) $\sqrt{2}\varepsilon_0 I_0$

3. In Young's double slit experiment, the two slits act as coherent sources of equal amplitude a and of wavelength λ. In other experiment with the same set up, the two slits are sources of equal amplitude a and wavelength λ, but are incoherent. The ratio of intensity of light at the mid point of the screen in the first case to that in the second case is

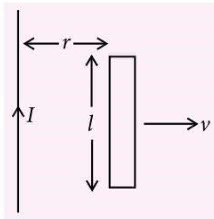
(a) 2 : 1 (b) 1 : 2
(c) 3 : 4 (d) 4 : 3

4. The given circuit It is equivalent to



(a) OR gate
(b) AND gate
(c) NOR gate
(d) NAND gate

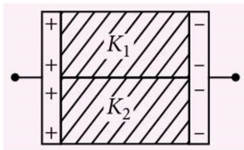
5. A conducting rod moves with constant velocity v perpendicular to the long, straight wire carrying a current I as shown in the figure. The emf generated between the ends of the rod is



(a) $\dfrac{\mu_0 v I l}{\pi r}$ (b) $\dfrac{\mu_0 v I l}{2\pi r}$

(c) $\dfrac{2\mu_0 v I l}{\pi r}$ (d) $\dfrac{\mu_0 v I l}{4\pi r}$

6. If two dielectrics are placed in a parallel plate capacitor as shown. Then, find the equivalent dielectric constant of the system



(a) $K_{eq} = \dfrac{K_1 + K_2}{2}$ (b) $K_{eq} = \dfrac{2}{K_1 + K_2}$

(c) $K_{eq} = K_1 + K_2$ (d) $K_{eq} = \dfrac{1}{K_1 + K_2}$

7. If refractive index of material of a prism with prism angle A is $\mu = \cot\dfrac{A}{2}$, then angle of minimum deviation will be

(a) $180° - A$ (b) $180° - 2A$
(c) $180° - 3A$ (d) $180° - 4A$

8. Four charges each with charge $+q$ are placed at the four corners of a square of side l, a charge $\frac{-q}{4}$ is at centre of the square. Force on the charge at the centre due to other charges is (where $K = 1/4\pi\varepsilon_0$)

(a) $\frac{Kq^2}{l^2}$ (b) $K\frac{\sqrt{2}q^2}{l^2}$

(c) zero (d) $K\frac{2\sqrt{2}q^2}{l^2}$

9. A charged particle moves in a magnetic field $\vec{B} = 10\hat{i}$ with initial velocity $\vec{u} = 5\hat{i} + 4\hat{j}$. The path of the particle will be

(a) straight line (b) circle

(c) helical path (d) None of these

10. A light beam, $E = 100\ [\sin(\omega_1 t) + \sin(\omega_2 t)]$ V m^{-1} with $\omega_1 = 5 \times 10^{15}$ rad s^{-1} and $\omega_2 = 8 \times 10^{15}$ rad s^{-1}, falls on a metal surface of work function 2.0 eV. Maximum kinetic energy of emitted photoelectrons is

(a) 3.20 eV (b) 1.5 eV (c) 3.27 eV (d) 2.1 eV

11. The electric field part of an electromagnetic wave in a medium is represented by $E_x = 0$;

$$E_y = 2\cdot 5\text{N C}^{-1}\cos\left[\left(2\pi\times10^6\text{rad s}^{-1}\right)t - \left(\pi\times10^{-2}\text{rad m}^{-1}\right)x\right]$$

$E_z = 0$. The wave is

(a) moving along the x-direction with frequency 10^6 Hz and wavelength 100 m

(b) moving along x-direction with frequency 10^6 Hz and wavelength 200 m

(c) moving along $-x$ direction with frequency 10^6 Hz and wavelength 200 m

(d) moving along y-direction with frequency $2\pi \times 10^6$ Hz and wavelength 200 m

12. 90% of the active nuclei present in a radioactive sample are found to remain undecayed after 1 day. The percentage of undecayed nuclei left after two days will be

(a) 85% (b) 81%

(c) 80% (d) 79%

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

13. **Assertion :** If a rod has a resistance 4 Ω is turned into semicircle, then its resistance along its diameter is 1.0 Ω.

Reason : On bending a rod, its length decreases and hence resistance decreases.

14. **Assertion :** Charge never flows from a condenser of higher capacity to the condenser of lower capacity.

Reason : Direction of flow of charge is determined by the difference in charge in the two condenser.

15. **Assertion :** When radius of a circular wire carrying current is doubled, its magnetic moment becomes four times.

Reason : Magnetic moment depends on area of the loop.

JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. There is a stream of neutrons with a kinetic energy of 0.0327 eV. If the half-life of neutrons is 700 s, what fraction of neutrons will decay before they travel a distance of 10 m?

Given, mass of neutron = 1.676×10^{-27} kg.

(a) 4.8×10^{-5} (b) 3.9×10^{-6}

(c) 8.4×10^{-5} (d) 2.3×10^{-6}

17. A thin circular ring of area A is held perpendicular to a uniform field of induction B. A small cut is made in the ring and a galvanometer is connected across the ends such that the total resistance of the circuit is R. When the ring is suddenly squeezed to zero area, the charge flowing through the galvanometer is

(a) $\frac{BR}{A}$ (b) $\frac{AB}{R}$ (c) ABR (d) $\frac{B^2A}{R^2}$

18. A ray of light enters a rectangular glass slab of refractive index $\sqrt{3}$ at an angle of incidence 60°. It travels a distance of 5 cm inside the slab and emerges out of the slab. The perpendicular distance between the incident and the emergent rays is

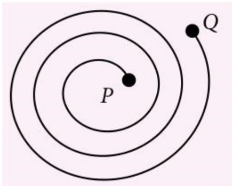
(a) $5\sqrt{3}$ cm (b) $\frac{5}{2}$ cm

(c) $5\sqrt{\frac{3}{2}}$ cm (d) 5 cm

19. An electromagnetic wave of frequency $\upsilon = 3.0$ MHz passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4.0$. Then
(a) wavelength is doubled and the frequency remains unchanged
(b) wavelength is doubled and frequency becomes half
(c) wavelength is halved and frequency remains unchanged
(d) wavelength and frequency both remain unchanged.

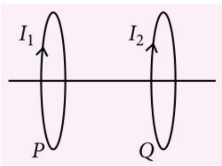
More than One Options Correct Type

20. A charged particle enters into a region which offers a resistance against its motion and a uniform magnetic field exists in the region. The particle traces a spiral path as shown in figure. Which of the following statements are correct?



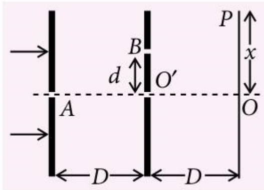
(a) Component of magnetic field in the plane of spiral is zero.
(b) The particle enters the region at Q.
(c) If magnetic field is outward, then the particle is positively charged.
(d) If magnetic field is outward, then the particle is negatively charged.

21. Two circular coils P and Q are fixed coaxially and carry currents I_1 and I_2 respectively as shown in figure. Mark the correct options.



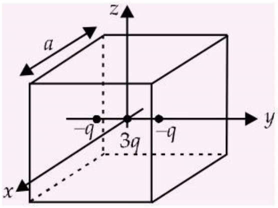
(a) If $I_2 = 0$ and P moves towards Q, a current in the same direction as I_1 is induced in Q
(b) If $I_1 = 0$ and Q moves towards P, a current in the opposite direction to that of I_2 is induced in P.
(c) When $I_1 \neq 0$ and $I_2 \neq 0$ are in the same direction then the two coils tend to move apart.
(d) When $I_1 \neq 0$ and $I_2 \neq 0$ are in opposite directions then the coils tends to move apart.

22. The minimum value of d so that there is a dark fringe at O is d_{min}. For the value of d_{min}, the distance at which the next bright fringe is formed is x. Then



(a) $d_{min} = \sqrt{\lambda D}$
(b) $d_{min} = \sqrt{\dfrac{\lambda D}{2}}$
(c) $x = \dfrac{d_{min}}{2}$
(d) $x = d_{min}$

23. A cubical region of side a has its centre at the origin. It encloses three fixed point charges, $-q$ at $\left(0, \dfrac{-a}{4}, 0\right)$, $+3q$ at (0, 0, 0) and $-q$ at $\left(0, +\dfrac{a}{4}, 0\right)$. Choose the correct option(s).



(a) The net electric flux crossing the plane $x = +\dfrac{a}{2}$ is equal to the net electric flux crossing the plane $x = -\dfrac{a}{2}$.
(b) The net electric flux crossing the plane $y = +\dfrac{a}{2}$ is more than the net electric flux crossing the plane $y = -\dfrac{a}{2}$
(c) The net electric flux crossing the entire region is $\dfrac{q}{\varepsilon_0}$
(d) The net electric flux crossing the plane $z = +\dfrac{a}{2}$ is equal to the net electric flux crossing the plane $x = +\dfrac{a}{2}$

Integer Answer Type

24. A square loop of side $a = 6$ cm carries a current $I = 1$ A. Calculate magnetic induction B (in μT) at point P, lying on the axis of loop and at a distance $x = \sqrt{7}$ cm from the center of loop.

25. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = \kappa r^a$, where κ and a are constants and r is the distance from its centre. If the electric field at $r = R/2$ is 1/8 times that at $r = R$, find the value of a.

26. A silver ball of radius 4.8 cm is suspended by a thread in a vacuum chamber. Ultraviolet light of wavelength 200 nm is incident on the ball for some time during which a total light energy of 1.0×10^{-7} J falls on the surface. Assuming that on the average, one photon out of ten thousand photons is able to eject a photoelectron, find the electric potential (in $\times 10^{-1}$ V) at the surface of the ball assuming zero potential at infinity.

Comprehension Type

In a mixture of H – He^+ gas (He^+ is singly ionized He atom), H atoms and He^+ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He^+ ions (by collisions). Assume that the Bohr model of atom is exactly valid.

27. The quantum number n of the state finally populated in He^+ ions is

(a) 2 (b) 3 (c) 4 (d) 5

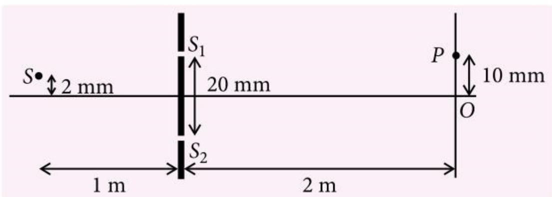
28. The wavelength of light emitted in the visible region by He^+ ions after collisions with H atoms is

(a) 6.5×10^{-7} m (b) 5.6×10^{-7} m

(c) 4.6×10^{-7} m (d) 4.0×10^{-7} m

Matrix Match Type

29. In Young's double-slit experiment, the point source S is placed above the central axis as shown in figure and the interference pattern was obtained. Now he pasted a transparent paper of thickness 0.02 mm and refractive index 1.45 in front of slit S_1 and again obtained the pattern. Column II contains the nature and order of fringe and Column I contains positions on the screen. If λ = 500 nm, then match column I with column II.



	Column I		Column II
(A)	At P, before pasting transparent paper	(P)	Bright fringe of order 80
(B)	At O, before pasting transparent paper	(Q)	Bright fringe of order 262
(C)	At P, after pasting the transparent paper	(R)	Bright fringe of order 62
(D)	At O, after pasting the transparent paper	(S)	Bright fringe of order 280

	A	B	C	D
(a)	P	R	S	Q
(b)	Q	R	S	P
(c)	P	Q	S	R
(d)	S	P	Q	R

30. Column I shows the state of motion of a charged particle. Column II shows the possible combination of electric field and magnetic field under which the path in column I is possible. Match column I with column II.

	Column I		Column II
(A)	Charge at rest experience a force.	(P)	$E = 0, B = 0$
(B)	A charge in motion goes undeviated with same velocity.	(Q)	$E \neq 0, B \neq 0$
(C)	A charge in motion goes undeviated with varying speed.	(R)	$E = 0, B \neq 0$
(D)	A charged particle undergoes helical motion.	(S)	$E \neq 0, B = 0$

	A	B	C	D
(a)	Q,S	P,Q,R	Q,S	Q,R
(b)	P,R	R,S	Q,R	R,S
(c)	P,R	Q,S	Q,R	Q,S
(d)	Q	P,S	R,Q	Q,S

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Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted ......

No. of questions correct ......

Marks scored in percentage ......

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.